IBM TotalStorage LTO Ultrium
Tape Drive

SCSI Reference

GA32-0450-03

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Note
Before using this manual and the product it supports, read the information under "Notices," on page 163.

Fourth Edition (March 2005)

This edition applies to the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference* and to all subsequent releases and modifications unless otherwise indicated in new editions.

Read This First

This is the fourth edition of the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference* (March 2005).

Summary of Changes

Second Edition, April 2004

The following changes were made in this edition:

- Added features of the 3580 Tape Drive Models L23 and H23.
- Modified to show that the generation 2 drive code ignores the Page Control (PC) field.
- Modified parameters and descriptions in Table 40 on page 35.
- Modified Table 41 on page 36 to show added support for TapeAlerts 51, 52, and 53 and to show removed claim support for flags 19, 35, and 38.
- Modified the Medium Type field definition in section“Mode Parameter Header” on page 51.
- Modified sections“Data Compression Mode Page” on page 55 and “Sequential Access Device Configuration Page” on page 56 to reflect that now the Emerald drive’s behavior matches that of the Sapphire drive.
- Modified the Text Generation value in Table 91 on page 81.
- Modified sectionTable 92 on page 82 to show that Medium Auxiliary Memory parameters 1400h-17FFh of Application Specific Data can be writen to Cartridge Memory as long as space is available.
- Modified section“READ POSITION” on page 94 to correctly state the behavior of the READ POSITION command after a READ type command.
- Modified section“SET CAPACITY” on page 128 to show that Check Condition status is returned with Illegal Field in CDB (5/2400h) if the Capacity Proportion Value of a new cartridge becomes smaller than 17.2 GB.

Third Edition, December 2004

The following changes were made in this edition:

- Added Generation 3 (Ultrium 3 Support).
- Added LTO Gen 3 log pages, as appropriate.
- Added support for IBM TotalStorage 3580 Tape Drive Models L33/L3H.
- Added support for IBM TotalStorage Ultrium 3 Tape Drive.
- Added support for IBM TotalStorage 400 GB Data Cartridge.
- Added new required items to Inquiry pages in the section entitled “INQUIRY” on page 16.
- Changed values of BQue field and CmdQ field in the section entitled “Standard Inquiry Data” on page 17.
- Added new log sense data and additional supported log pages (see “LOG SENSE” on page 31).
- Replaced TapeAlert Log Parameters in Table 41 on page 36.
- Created a mode page that can be saved and used to configure behavior changes to a drive (see “Behavior Configuration Mode Page” on page 63).

- Added speed matching and defined a byte field to be used to distinguish between a full performance drive and a non-performance limited drive (see "Sense Data Format" on page 105).

Fourth Edition, March 2005

The following changes were made in this edition:

- Added Fibre Channel support.

Contents

Tables

Preface

This publication contains information about how to use and program all models of the IBM® LTO Ultrium Tape Drive.

Organization

The information in this book is organized as follows:

- Chapter 1, "Introduction," on page 1 describes the features and supported attachments for each type of tape drive.
- Chapter 2, "Summary of Drive Generation Differences," on page 7 lists the differences in command timeout values between the IBM Ultrium Internal Tape Drive, the IBM TotalStorage LTO Ultrium 2 Tape Drive, and the IBM TotalStorage LTO Ultrium 3 Tape Drive (known respectively as the Generation 1, Generation 2, and Generation 3 drives).
- Chapter 3, "Command Support," on page 13 lists the SCSI commands that are supported by the tape drives.
- Chapter 4, "Error Sense Information," on page 141 describes the error sense information for the tape drives.
- Chapter 6, "Sense Keys and Additional Sense," on page 147 describes the sense keys and additional sense information for the tape drives.
- Chapter 7, "Attachment Features," on page 153 describes the features of the SCSI and Fibre Channel tape drives.

Related Publications

- *IBM TotalStorage Ultrium Tape Drive 3580 Models L23 and H23 Setup and Operator Guide*, GA32-0460, tells how to install and run the IBM 3580 Ultrium Tape Drive Models L23 and H23.
- *IBM 3580 Ultrium Tape Drive Setup, Operator, and Service Guide*, GA32-0415, tells how to install and run the IBM 3580 Ultrium Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F Setup, Operator, and Service Guide*, GA32-0455, tells how to install and run the IBM Ultrium 2 Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM TotalStorage 3580 Tape Drive Models L33/L3H Setup, Operator, and Service Guide*, GC26-7708, tells how to install and run the IBM 3580 Tape Drive Models L33/L3H. The guide also describes how to administer basic service procedures.
- *IBM TotalStorage Ultrium 3 Tape Drive Setup, Operator, and Service Guide*, GC26-7697, tells how to install and run the IBM TotalStorage Ultrium 3 Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM Ultrium Internal Tape Drive Models T200 and T200F Setup, Operator, and Service Guide*, GA32-0435, tells how to install and run the IBM Ultrium Internal Tape Drive. The guide also describes how to administer basic service procedures.
- *IBM Ultrium Device Drivers Installation and User's Guide*, GA32-0430, provides instructions for attaching IBM-supported hardware to open-systems operating systems. It indicates what devices and levels of operating systems are supported, gives the requirements for adapter cards, and tells how to configure servers to use the device driver with the Ultrium family of devices.

- *IBM Ultrium Device Drivers Programming Reference*, GC35-0483, supplies information to application owners who want to integrate their open-systems applications with IBM-supported Ultrium hardware. The reference contains information about the application programming interfaces (APIs) for each of the various supported operating-system environments.
- *Fibre Channel Arbitrated Loop (FC-AL-2)*, published by the American National Standards Institute (ANSI) as NCITS 332:1999.
- *Fibre Channel Tape and Tape Medium Changers (FC-TAPE)*, published by the American National Standards Institute. Final draft available as T11/99-069v4 on the web at `http://www.t11.org`; actual document available from ANSI as NCITS TR-24:1999.
- *Fibre Channel Protocol for SCSI*, Second Version (FCP-2), published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Parallel Interface-3 (SPI-3)*, published by InterNational Committee on Information Technology Standards (INCITS) and available on the web at `http://www.t10.org`.
- *SCSI-3 Stream Commands (SSC)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Stream Commands-2 (SSC-2)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Primary Commands-2 (SPC-2)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.
- *SCSI Primary Commands-3 (SPC-3)*, published by the American National Standards Institute and available on the web at `http://www.t10.org`.

Portions of this manual were adapted from documentation provided by the InterNational Committee on Information Technology Standards (INCITS).

Chapter 1. Introduction

The products that are discussed in this book are high-performance, high-capacity data-storage devices that connect to and provide additional storage for supported servers. They include all models of the IBM LTO Ultrium Tape Drive, such as:

- IBM Ultrium Internal Tape Drive Models T200 and T200F (known as Generation 1)
- IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F (known as Generation 2)
- IBM 3580 Ultrium External Tape Drive Models L11/H11, L13/H13, L23/H23, and L33/L3H
- IBM TotalStorage Ultrium 3 Tape Drive Model T800 (known as Generation 3)

Certain of the products use a Small Computer Systems Interface (SCSI); others use a Fibre Channel interface. Table 1 on page 2 lists the type of interface and other features for each product.

Figure 1 shows the IBM 3580 Ultrium Tape Drive and the IBM TotalStorage LTO Ultrium Tape Drive Model T200. The IBM TotalStorage Ultrium Tape Drive Model T800 looks similar to the IBM TotalStorage LTO Ultrium Tape Drive Model T200.

Figure 1. The IBM 3580 Ultrium Tape Drive and the IBM TotalStorage LTO Ultrium Tape Drive Model T200. Model T200 resembles Model T200F, T400, and T400F in appearance. It is shown on the right without a front bezel. The IBM TotalStorage Ultrium Tape Drive Model T800 looks similar to the IBM TotalStorage LTO Ultrium Tape Drive Model T200.

Designed to perform unattended backups as well as to retrieve and archive files, the Ultrium Tape Drives include the features that are described in Table 1.

Table 1. Features of the IBM Ultrium Tape Drives and the IBM 3580 Ultrium Tape Drive

Feature	Ultrium Tape Drives			3580 Tape Drive		
	Model T200	**Model T400**	**Model T800**	**Models L11/H11, L13/H13**	**Models L23/H23**	**Models L33/L3H**
	Model T200F	**Model T400F**	**Model T800F**			
Native storage capacity	100 GB	200 GB	400 GB	100 GB	200 GB	400 GB
	100 GB	200 GB	400 GB			
Storage capacity at 2:1 compression	200 GB	400 GB	800 GB	200 GB	400 GB	800 GB
	200 GB	400 GB	800 GB			
Native sustained data transfer rate	15 MB	35 MB	80 MB	15 MB	35 MB	80 MB
	15 MB	35 MB	80 MB			
Data transfer rate at 2:1 compression	30 MB	70 MB	160 MB	30 MB	70 MB	160 MB
	30 MB	70 MB	160 MB			
Burst data transfer rate	80 MB/s	160 MB/s	160 MB/s	40 to 80 MB/s, depending on model	160 MB (Model L23)	200 MB/s
	100 MB/s	200 MB/s	200 MB/s			
Type of interface	Ultra2 LVD/SE SCSI	Ultra 160 LVD SCSI	Ultra 160 LVD SCSI	Ultra2 SCSI LVD or HVD	Ultra160 SCSI LVD or HVD	Single-port, LC-Duplex Fibre Channel, with the use of SCSI protocol
	SC-Duplex Fibre Channel, with the use of SCSI protocol	Single-port, LC-Duplex Fibre Channel, with the use of SCSI protocol	Single-port, LC-Duplex Fibre Channel, with the use of SCSI protocol			
Note: All sustained data rates are dependent on the capabilities of the interconnect (for example, an UltraSCSI bus is limited to less than 40MB/sec).						

Supported Servers and Operating Systems

The Ultrium Tape Drives are supported by a wide variety of servers and operating systems, as well as adapters. These attachments can change throughout the products' life cycles. To determine the latest supported attachments, visit the web at `http://www.ibm.com/storage/lto` and click on Technical Support or LTO Support.

SCSI and Fibre Channel Attachment

The Ultrium Tape Drives attach to servers and operating systems shown in Table 2. An attachment includes (but is not limited to) the servers and operating systems in the table. Supported interfaces are as follows:

- The Ultrium Tape Drive Models T200 and T400, and the 3580 Ultrium Internal Tape Drive use a SCSI interface
- The Ultrium Tape Drive Models T200F and T400F use a Fibre Channel interface

For specific instructions about attachment, see one or more of the following:

- The chapter about installation in the *IBM Ultrium Internal Tape Drive Models T200 and T200F Setup, Operator, and Service Guide*
- *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F Setup, Operator, and Service Guide*
- *IBM 3580 Ultrium Tape Drive Setup, Operator, and Service Guide* for Models L11, H11, L13, and H13
- *IBM TotalStorage Ultrium Tape Drive 3580 Models L23 and H23 Setup and Operator Guide*
- *IBM TotalStorage 3580 Tape Drive Models L33/L3H Setup, Operator, and Service Guide*
- *IBM TotalStorage Ultrium 3 Tape Drive Setup, Operator, and Service Guide*

Table 2. Supported Servers and Operating Systems for SCSI and Fibre Channel Attachment

Supported Servers	**Supported Operating Systems**
IBM AS/400® or @server iSeries™	OS/400®
IBM RS/6000®, RS/6000 SP™, or @server pSeries™	AIX®
IBM @server zSeries™ 800 or 900	Linux
Hewlett-Packard	HP-UX
Sun Microsystems	Solaris
32-bit, Intel-compatible servers	Microsoft®Windows® 2000 or Windows NT®
	Red Hat Linux
64-bit, Intel Itanium servers	Red Hat Linux
Supported SAN Components for Fibre Channel Attachment Visit the web at: `http://www.storage.ibm.com/hardsoft/tape/supserver/support.html`	

Supported Device Drivers

IBM maintains the latest levels of device drivers and driver documentation for the IBM Ultrium Tape Drives on the Internet. You can access this material from your browser or through the IBM FTP site by performing one of the following procedures. **(Note: If you do not have Internet access and you need information about device drivers, contact your Marketing Representative.)**

- Using a browser, type one of the following:
  - `http://www.ibm.com/storage`
  - `ftp://ftp.software.ibm.com/storage/devdrvr`
  - `ftp://207.25.253.26/storage/devdrvr`
- Using an IBM FTP site, enter the following specifications:
  - FTP site: `ftp.software.ibm.com`
  - IP Addr: `207.25.253.26`
  - Userid: `anonymous`
  - Password: (use your current e-mail address)
  - Directory: `/storage/devdrvr`

IBM provides PostScript- and PDF-formatted versions of its documentation in the /storage/devdrvr/doc directory:

- IBM_ultrium_tape_IUG.ps and IBM_ultrium_tape_IUG.pdf contain the current version of the *IBM Ultrium Device Drivers Installation and User's Guide*
- IBM_ultrium_tape_PROGREF.ps and IBM_ultrium_tape_PROGREF.pdf contain the current version of the *IBM Ultrium Device Drivers Programming Reference*

Device drivers and utilities for each supported server are beneath /storage/devdrvr/ in the following directories (the device driver for the iSeries or AS/400 server is included in the OS/400 operating system):

- AIX
- HPUX
- Linux
- Solaris
- Tru64
- WinNT
- Win2000

For more information about device drivers, refer to any of the preceding directories.

Supported Tape Cartridges

The IBM LTO Ultrium Tape Drives support LTO Cartridges as described in Table 3.

Table 3. IBM LTO Ultrium Tape Drive Support of LTO Cartridges

LTO Generation	Type	Data Capacity Native	Data Capacity Compressed	Supported by Ultrium 3	Supported by Ultrium 2	Supported by Ultrium 1
3	A	400 GB	800 GB	Yes	No	No
2	A	200 GB	400 GB	Yes	Yes	No
1	A	100 GB	200 GB	Yes — Read Only	Yes	Yes
1	B	50 GB	100 GB	Yes — Read Only	Yes	Yes
1	C	30 GB	60 GB	Yes — Read Only	Yes	Yes
1	D	10 GB	20 GB	Yes — Read Only	Yes	Yes

The Ultrium 3 Tape Drive (Generation 3) uses the IBM TotalStorage 400 GB Data Cartridge, and is compatible with the cartridges of its predecessors (called Generation 1 and Generation 2). The Ultrium 3 Tape Drive performs the following functions:

- Reads and writes Generation 3 cartridges to Generation 3 format
- Reads and writes Generation 2 cartridges to Generation 2 format
- Reads Generation 1 cartridges in Generation 1 format
- Does not write Generation 3 cartridges to Generation 2 or Generation 1 format
- Does not write Generation 2 cartridges to Generation 3 or Generation 1 format
- Does not write Generation 1 cartridges to Generation 3 or Generation 2 format

The Ultrium 3 Tape Drive reads tapes that have been written by other licensed Ultrium 3 drives. It also writes tapes that can be read by other licensed Ultrium 3 drives.

Ultrium 3 Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges that have capacities of 400 and 200 GB. They also offer read capability for certified LTO Ultrium tape cartridges that have a capacity of 100 GB.

The Ultrium 2 Tape Drive (Generation 2) uses the IBM TotalStorage LTO Ultrium 200 GB Data Cartridge and is compatible with the cartridges of its predecessor, the IBM Ultrium Internal Tape Drive (called Generation 1). The Ultrium 2 Tape Drive performs the following functions:

- Reads and writes Generation 2 cartridges to Generation 2 format
- Reads and writes Generation 1 cartridges to Generation 1 format
- Does not write Generation 2 cartridges to Generation 1 format
- Does not write Generation 1 cartridges to Generation 2 format

The Ultrium 2 Tape Drive reads tapes that have been written by other licensed Ultrium 2 drives. It also writes to tapes that can be read by other licensed Ultrium 2 drives.

Ultrium 2 Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges that have capacities of 200 and 100 GB.

Ultrium 1 Tape Drives offer read/write capability for certified LTO Ultrium tape cartridges that have a capacity of 100 GB.

Chapter 2. Summary of Drive Generation Differences

This chapter provides a summary of the differences in host attachment protocol between the Ultrium Internal Tape Drive (Generation 1), the TotalStorage LTO Ultrium 2 Tape Drive (Generation 2), and the TotalStorage Ultrium 3 Tape Drive (Generation 3).

The features of the Generation 2 drive that differ from the Generation 1 drive include:

- 64-MB read-and-write cache
- Speed matching
- Channel calibration
- SET CAPACITY SCSI command
- Ultra160 SCSI interface
- Drive external SCSI termination required
- Fibre Channel 2-Gb/s interface
- Fibre Channel support for direct connection to an F port (for example, a McData switch)

The features of the Ultrium 3 Tape Drive that differ from those of the Ultrium 2 Tape Drive include the following:

- 128 MB read-and-write cache
- New media, new media shell color (dark bluish gray, Pantone color number 7546C)
- Expanded request sense length to 96 bytes

Differences in Command Timeout Values

Due to differences between each of the of the Ultrium drives, the maximum amount of time it takes for various SCSI commands to execute and return status has changed. Table 4 on page 8 provides a list of all recommended host command timeouts from commands defined by the referenced SCSI-3 standard or by this product as vendor-unique for sequential access devices. The table lists the following information for each command: the operation code, recommended timeout, and notes.

It is strongly recommended that device drivers or host software implement device reservations using the Reserve or Persistent Reserve commands. Due to the sequential nature of tape devices, many host commands are serialized, and command timeouts consequently have an additive effect. Using reservations will prevent this from causing application disruptions in a multi-initiator or SAN environment. Similar additive timeout effects can occur if the host is using command queueing (that is, simple queuing).

Note: The timeouts in the following table are based on the time from the start of execution of the command, to its reported completion. Since applications are generally concerned with the time from the command being issued, to its reported completion, it should be noted that this overall time may be affected by currently executing operations. Some of these conditions include:

- A prior command was issued with the Immediate bit set in the CDB

- Multiple concurrent commands with Simple queueing are executed
- Multi-initiator configurations without reservations
- Non-host operations, such as manual unloads, power-on self tests, and so on
- Commands issued shortly after certain aborted commands
- Commands that force flushes when unwritten write data is in the buffer

Table 4. Command Timeout Values

Op Code	Command	Timeout for Ultrium Tape Drive (in minutes)	Timeout for Ultrium 2 Tape Drive (in minutes)		Timeout for Ultrium 3 Tape Drive (in minutes)		
			Gen 1 Cartridge	Gen 2 Cartridge	Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge
00h	Test Unit Ready	1	1	1	1	1	1
01h	Rewind	8	9	8	8	8	9
03h	Request Sense	1	1	1	1	1	1
05h	Read Block Limits	1	1	1	1	1	1
08h	Read	18	18	18	16	16	17
0Ah	Write	18	18	18	N/A	16	18
0Bh	Set Capacity	N/A	13	13	N/A	11	12
10h	Write FileMark	15	15	15	N/A	15	17
11h	Space (normal)	16	15	14	14	14	16
	Space (slow)	173	138	151	127	165	140
12h	Inquiry	1	1	1	1	1	1
13h	Verify	18	18	18			
15h/55h	Mode Select (6/10)	1	1	1	1	1	1
16h/56h	Reserve Unit (6/10)	1	1	1	1	1	1
17h/57h	Release Unit (6/10)	1	1	1	1	1	1
19h	Erase	204	138	151	N/A	160	134
1Ah/5Ah	Mode Sense (6/10)	1	1	1	1	1	1
1Bh	Load (Cartridge Insert -> BOM)	11	12	12	8	8	8
	Load (Lp4 -> BOM)	8	9	8	8	8	9
	Unload (BOM -> Cartridge Eject)	10	10	10	10	10	11
	Unload (LP4 -> Cartridge Eject)	11	12	11	11	11	12
1Ch	Receive Diagnostic Results	1	1	1	1	1	1
1Dh	Send Diagnostic	29	35	35	13	39	34

Table 4. Command Timeout Values (continued)

Op Code	Command	Timeout for Ultrium Tape Drive (in minutes)	Timeout for Ultrium 2 Tape Drive (in minutes)		Timeout for Ultrium 3 Tape Drive (in minutes)		
			Gen 1 Cartridge	Gen 2 Cartridge	Gen 1 Cartridge	Gen 2 Cartridge	Gen 3 Cartridge
1Eh	Prevent/Allow Medium Removal	1	1	1	1	1	1
2Bh	Locate (normal)	16	15	14	14	14	16
	(slow)	173	138	151	127	165	140
34h	Read Position	1	1	1	1	1	1
3Bh	Write Buffer	8	8	8	8	8	8
3Ch	Read Buffer	8	8	8	7	7	8
44h	Report Density Support	1	1	1	1	1	1
4Ch	Log Select	1	1	1	1	1	1
4Dh	Log Sense	1	1	1	1	1	1
5Eh	Persistent Reserve In	1	1	1	1	1	1
5Fh	Persistent Reserve Out	1	1	1	1	1	1
8Ch	Read Attribute	1	1	1	1	1	1
8Dh	Write Attribute	1	1	1	1	1	1
A0h	Report LUNs	1	1	1	1	1	1
	Indicates largest value for all columns						

Additional Commands and Parameters in Generation 2 and Generation 3

The following are new commands and parameters added to Generation 2:

Set Capacity Command — The SET CAPACITY command is supported on Ultrium 2 and Ultrium 3 tape drives. The minimum capacity allowed varies from one generation to another. For more information, see "SET CAPACITY" on page 128.

Echo Buffer Support — Ultrium 2 and Ultrium 3 drives support the Echo Buffer mode of the READ BUFFER and WRITE BUFFER commands (see pages 89 and 137, respectively).

Data Changes Between Generations

The sections that follow describe the data changes between Generations of the Ultrium tape drive.

Standard Inquiry Data

The length of Standard Inquiry data on Ultrium 2 and Ultrium 3 drives is 57 bytes. The Standard Inquiry data reported by Ultrium drives is shown in Table 9 on page 17. The Additional Length field specifies how many bytes are returned. Currently, Ultrium 1 devices set this value to 33 (21h) and Ultrium 2 and Ultrium 3 devices set this value to 53 (35h). This value is subject to change and it is strongly recommended that the user parse that data returned by using the Additional Length field instead of the published values.

Product Identification information returned is shown in Table 10 on page 18.

For more information, see "Standard Inquiry Data" on page 17.

REPORT DENSITY SUPPORT Command

The REPORT DENSITY SUPPORT command has been changed to add Ultrium 3 density values.

Table 5. Density Values

Field	Ultrium 1	Ultrium 2	Ultrium 3
Primary density code	40h	42h	44h
Secondary density code	40h	42h	44h
Bits per mm	4880	7398	9638
Media width (in tenths of mm)	127	127	127
Tracks	384	512	704
Capacity (in 2^{20} bytes)	95,367	190,734	381,469
Assigning organization	LTO-CVE	LTO-CVE	LTO-CVE
Density name	U-18	U-28	U-316
Description	Ultrium 1/8T	Ultrium 2/8T	Ultrium 3/16T

For more information, see "REPORT DENSITY SUPPORT" on page 99.

Mode Pages

For Ultrium 1 devices, the Medium Type field is not used and must be set to 0.

For Ultrium 2 and Ultrium 3 devices, the Medium Type field on Mode Sense data is set to 00h for when no media is loaded, 18h when Ultrium 1 media is loaded, 28h when Ultrium 2 media is loaded, and 38h when Ultrium 3 media is loaded. On Mode Select commands, any value is allowed and ignored.

Fibre Channel Port Control Page (19h) Page Length changed from 0Eh in Ultrium 1 drives to 06h in Ultrium 2 and Ultrium 3 drives. This matches the current definition in the SCSI standards (FCP-2). For more information, see "Fibre Channel Port Control Page" on page 59.

READ POSITION Command

The READ POSITION command for Ultrium 2 and Ultrium 3 behaves as described in the SCSI standards (SPC-2). For more information, see "READ POSITION" on page 94.

Request Sense Changes

Ultrium 3 drives have expanded the sense data. For Ultrium 2 and Ultrium 3 drives, the Additional Sense Length is set to *n*-7, and is at least 10. When the sense data is associated with an Illegal Length read, the Additional Sense Length may be 10. In Ultrium 1 and Ultrium 2 drives, *n* can be as large as 35. In Ultrium 3 drives, *n* can be as large as 95. While this length in Ultrium 3 drives is not anticipated to change, it is recommended that the Additional Sense Length be used to parse that data. For more information, see "REQUEST SENSE" on page 105.

Behavior Changes

Cartridge Eject for Errors

Ultrium 2 and Ultrium 3 drives do not auto-eject data cartridges when errors occur during loads.

Queueing Issues

For Ultrium 2 and Ultrium 3 drives, when a cartridge is inserted into the drive through means other than SCSI commands to LUN 0, it is assumed that the host will poll the drive with TEST UNIT READY commands to determine its readiness before issuing in-order commands (for example, commands other than INQUIRY, TEST UNIT READY, REQUEST SENSE, or REPORT LUNS). If this is not the case, these commands may time out in ERP (Error Recovery Procedure) situations.

Microcode Detection of Errors

The drive microcode is designed to check for logic errors, to handle hardware-detected errors, and to detect and report microcode-related errors.

Fencing Behavior

For a description of the Fencing Behavior and Persistent Error handling, see "Persistent Errors" on page 142.

Chapter 3. Command Support

In the sections that follow, each SCSI command includes a table that describes the fields in the Command Descriptor Block (CDB). The table is similar to those published by the InterNational Committee for Information Technology Standards (INCITS). It includes bit numbering conventions that conform to ANSI standards. The conventions are as follows:

- Bit 0 is the least significant bit (LSB) and occupies the right bit position in the table
- Bits 1-6 continue from right to left in ascending order
- Bit 7 is the most significant bit (MSB) and occupies the left bit position in the table

The LUN field in the CDB has been obsoleted in SCSI-3 and is ignored for every command.

Notes:

1. For this chapter, a megabyte (MB) is equal to 1 048 576 bytes.
2. Binary numbers are represented by numbers followed by `b`. Hexadecimal numbers are represented by `0-9` and `A-F` followed by `h`. Numbers with no suffix can be assumed to be decimal.

Table 6. Supported Common SCSI Commands

Command Name	Operation Code	SCSI Spec[1]	Page	Applicable Conditions[2]					
				RVC	UAT	NRD	WRP	MFC	DCC
ERASE	19h	SSC	15	y	y	y	y	y	y
INQUIRY	12h	SPC-2	16	-	-	-	-	-	-
LOAD/UNLOAD	1Bh	SSC	28	y	y	-	-	y	y
LOCATE	2Bh	SSC	29	y	y	y	-	y	y
LOG SELECT	4Ch	SPC-2	30	y	y	-	-	-	y
LOG SENSE	4Dh	SPC-2	31	y	-	-	-	-	-
MODE SELECT (6)	15h	SPC-2	49	y	y	-	-	-	y
MODE SELECT (10)	55h	SPC-2	49	y	y	-	-	-	y
MODE SENSE (6)	1Ah	SPC-2	50	-	y	-	-	-	-
MODE SENSE (10)	5Ah	SPC-2	50	-	y	-	-	-	-
PERSISTENT RESERVE IN	5Eh	SPC-2	66	y	y	-	-	-	-
PERSISTENT RESERVE OUT	5Fh	SPC-2	69	y[3]	y	-	-	-	-
PREVENT ALLOW MEDIUM REMOVAL	1Eh	SPC-2	73	y	y	-	-	-	-
READ	08h	SSC	74	y	y	y	-	y	y
READ ATTRIBUTE	8Ch	SPC-3	76	y	y	y	-	-	y
READ BLOCK LIMITS	05h	SSC	88	-	y	-	-	-	-
READ BUFFER	3Ch	SPC-2	89	y	-	-	-	-	-
READ POSITION	34h	SSC	94	y	y	-	-	-	-
RECEIVE DIAGNOSTIC RESULTS	1Ch	SPC-2	97	y	y	-	-	-	-
RELEASE UNIT (6)	17h	SPC-2	98	-	y	-	-	-	-
RELEASE UNIT (10)	57h	SPC-2	98	-	y	-	-	-	-

Table 6. Supported Common SCSI Commands (continued)

Command Name	Operation Code	SCSI Spec[1]	Page	Applicable Conditions[2]					
				RVC	UAT	NRD	WRP	MFC	DCC
REPORT DENSITY SUPPORT	44h	SSC	99	-	y	-	-	-	-
REPORT LUNs	A0h	SSC	103	-	-	-	-	-	-
REQUEST SENSE	03h	SPC-2	105	-	-	-	-	-	-
RESERVE UNIT (6)	16h	SPC-2	110	y	y	-	-	-	-
RESERVE UNIT (10)	56h	SPC-2	110	y	y	-	-	-	-
REWIND	01h	SSC	111	y	y	y	-	y	y
SEND DIAGNOSTIC	1Dh	SPC-2	112	y	y	-	-	y	y
SET CAPACITY	0Bh	SSC-2	128	y	y	y	y	y	y
SPACE	11h	SSC	130	y	y	y	-	y	y
TEST UNIT READY	00h	SSC	132	y	y	y	-	-	y
VERIFY	13h	SSC	133	y	y	y	-	y	y
WRITE	0Ah	SSC	134	y	y	y	y	y	y
WRITE ATTRIBUTE	8Dh	SPC-3	135	y	y	y	y	-	y
WRITE BUFFER	3Bh	SPC-2	134	y	y	-	-	-	-
WRITE FILE MARKS	10h	SSC	139	y	y	y	y	y	y

Note 1: SCSI specifications are as follows:

SSC-2 = *SCSI Stream Commands - 2*

SSC = *SCSI-3 Stream Commands*

SPC-2 = *SCSI Primary Commands-2*

SPC-3 = *SCSI Primary Commands-3*

Note 2: Applicable Conditions are as follows:

y = condition can apply to the command

- = condition cannot apply to the command

RVC = reservation conflict

UAT = unit attention

NRD = not ready

WRP = write protect

MFC = medium format corrupted

DCC = deferred check condition

Note 3: Reported as appropriate for the type of Service Action and Reservation Type requested and the current reservation state of the drive.

ERASE

Table 7. ERASE Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (19h)							
1	Logical Unit Number			Reserved			Immed	Long
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

EOD is written at the current position, which marks it as end of data.

If the Long field is set to 0, no further writing occurs. If the Long field is set to 1, the Data Set Separator (DSS) pattern is written from EOD to the end of the medium to overwrite any data that is currently on the tape.

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

After the command is successfully completed, the drive is positioned immediately before End Of Data (not End Of Tape).

INQUIRY

The INQUIRY command instructs the drive to return data about itself to the initiator.

Table 8. INQUIRY Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (12h)							
1	Logical Unit Number			Reserved				EVPD
2	Page Code							
3	Reserved							
4	Allocation Length							
5	Control							

If the Enable Vital Product Data (EVPD) field is set to 0 and the Page Code is 0, Standard Inquiry Data is returned.

If the Enable Vital Product Data (EVPD) field is set and the Page Code is 0, the Supported Vital Product Data Pages page is returned. This page lists the EVPD pages that are supported by the drive in this configuration.

If the Enable Vital Product Data (EVPD) field is set, if the Page Code is not 0, and if there is an Inquiry data page that corresponds to that page code, then that page is returned. See Table 11 on page 19 for supported data pages. The contents of pages 03h and D0h are not specified in this document.

If the preceding conditions do not apply, Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

Standard Inquiry Data

Table 9. Standard Inquiry Data Valid LUN

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier			Peripheral Device Type				
1	RMB	Reserved						
2	ISO version (00b)		ECMA version (000b)			Version (3h)		
3	AERC(0)	Obsolete	NACA(0)	HiSup(0)	Response Data Format (2h)			
4	Additional Length							
5	Reserved							
6	BQue(0)	EncSrv(0)	VS(0)	MultiP	MChngr(0)	Obsolete	Adr32(0)	Adr16
7	RelAdr(0)	Obsolete	WBs16	Sync	Linked(0)	TransDis(0)	CmdQ	VS(0)
8 : 15	Vendor Identification IBM							
16 : 31	Product Identification							
32 : 35	Product Revision Level: YMDV							
36	Reserved							AutDis
37	Performance Limit							
38 : 40	Reserved							
41	OEM Specific							
42 : 55	Reserved							
56	Reserved				Clocking		QAS (0b)	IUS (0b)
57	Reserved							

For Valid LUN:

- Peripheral Qualifier is set to 000b.
- Peripheral Device Type is set to 01h.
- RMB is set to 1b to indicate that the medium is removable.

For Invalid LUN:

- Peripheral Qualifier is set to 011b.

- Peripheral Device Type is set to 1Fh.
- RMB is set to 0b to indicate that the medium is *not* removable.

For SCSI device:

- Adr16 field is set to 1, which indicates that the drive supports 16 SCSI IDs.
- WBs16 field is set to 1, which indicates that the drive supports a 16-bit wide data path on a single cable.
- Sync field is set to 1, which indicates that the drive supports synchronous data transfers.
- CmdQ field is set to 0, which indicates that the drive does not command queueing.
- Clocking field is supported on Ultrium 2 and Ultrium 3 drives only and is set to 11b because the drive supports both ST and DT modes. On Ultrium 1 devices, this field is set to 00b.

For Fibre Channel devices:

- Adr16 field is set to 0.
- WBs16 field is set to 0.
- Sync field is set to 0.
- CmdQ field is set to 1, which indicates that the drive supports tagged (simple) command queueing.
- Clocking field is set to 0.

For all devices:

- The Additional Length field specifies how many bytes follow. Currently Ultrium 1 devices set this value to 33 (21h), and Ultrium 2 and Ultrium 3 devices set this value to 53 (35h). This value is subject to change and it is strongly recommended that the user parse the data returned by using the Additional Length field instead of the published values.
- Vendor Identification returns `IBM` in ASCII with trailing blanks.
- Product Vendor Identification returns `ULTxxxx-TDy` in ASCII with trailing blanks. If the drive is an IBM drive, `xxxx` equals 3580; if it is an OEM drive, `xxxx` equals RIUM. The character `y` indicates the generation of the drive. See Table 10 for the value returned.

Table 10. Product Identification Table

Generation	IBM Drive	OEM Drive
1	ULT3580-TD1	ULTRIUM-TD1
2	ULT3580-TD2	ULTRIUM-TD2
3	ULT3580-TD3	ULTRIUM-TD3

- Product Revision Level has four parts:
  - `Y` is the last character of the year (for example, 2 indicates the year 2002)
  - `M` is the month, in the alphanumeric set 1 through 9, A, B, or C
  - `D` is the day, in the alphanumeric set 1 through 9, A through V
  - `V` is the version, in the alphanumeric set 0 through 9, A through Z, with 0 being the earliest and Z the latest (to avoid interpretation errors, the characters i, l, and o are not used)
- If the Performance Limit field is set to 0, the drive is a full performing drive. If the Performing Limit field is set to a non-zero value, the Limit of the drive is

defined by the following equation:
Limit in MB/s = (Max Performance in MB/s) * ((Performance Limit) / 256)

- Automation Disabled (AutDis) field set indicates that the drive is not capable of full automation function. When this field is 0, it indicates that the drive is capable of full automation function.
- The OEM Specific field is intentionally not specified. See the documentation from the OEM vendor to determine the field's definition and application.
- Quick Arbitrate Supported (QAS) is set to 0 because the drive does not support quick arbitration and selection.
- Information Unit Supported (IUS) is set to 0 because the drive does not support information unit transfers.

Supported Vital Product Data Page

Table 11. Supported Vital Product Data Inquiry Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (00h)							
2	Reserved							
3	Page Length (n-3)							
supported VPD page list								
4	Supported Vital Product Data Page Code (00h):							
5	Vendor-Unique Page Code (03h)							
6	Unit Serial Number Page Code (80h)							
7	Device Identification Page Code (83h)							
8	Mode Page Policy Page Code (87h)							
9	SCSI Ports Page Code (88h)							
10	Sequential-Access Device Capabilities Page Code (B0h)							
11	Drive Component Revision Levels Page Code (C0h)							
12	Vendor-Unique Page Code (D0h)							

The Supported Vital Product Data Page contains pages that the device will return. Only those drives that have the AS/400 (iSeries) attachment enabled will have valid data in pages 03h and D0h. The contents of pages 03h and D0h are not specified in this document. OEM drives may add pages not specified in this document.

The Page Length field indicates how many bytes follow.

Unit Serial Number Page

Table 12. Unit Serial Number Inquiry Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (80h)							

Table 12. Unit Serial Number Inquiry Page (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
2	Reserved							
3	Page Length (0Ah)							
4 : 13	Unit Serial Number							

The Unit Serial Number Page contains a single value that is a 10-byte ASCII string. The string, with the Vendor Identification and Product Identification fields in the Standard Inquiry Data, uniquely identifies the drive. Valid Serial Number values are 0 through 9, A through D, and F.

Device Identification Page

Table 13. Device Identification Inquiry Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (83h)							
2	Reserved							
3	Page Length SCSI drives: (n-3) Fibre Channel drives: (m-3)							
4 : n	Device Identification Descriptor							
n : m	Fibre Channel Identification Descriptors							

SCSI devices return only the Device Identification Descriptor (see Table 14). Fibre Channel devices return the Device Identification Descriptor (see Table 14) followed by the Fibre Channel Identification Descriptors (see Table 16 on page 21).

Table 14. Device Identification Descriptor Format

Byte	Bit							
	7	6	5	4	3	2	1	0
4	Reserved				Code Set (2h)			
5	Reserved				Identifier Type			
6	Reserved							
7	Identifier Length (n-3)							

Table 14. Device Identification Descriptor Format (continued)

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
8 : n	Identifier							

Table 15 describes the Identifier format.

Table 15. Identifier Format

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
8 : 15	Vendor Identification							
16 : 31	Product Identification							
32 : 41	Serial Number							

The Code Set field is 2, indicating the Identification Descriptor contains only ASCII data.

This device supports an Identifier Type of 1. In this case, the Device Identification Descriptor is the Vendor Identification followed by the Product Identification field from the Standard Inquiry Data and the Serial Number field from the Unit Serial Number Inquiry Page (see "Unit Serial Number Page" on page 19).

The Parallel SCSI drive reports only the single Identification Descriptor of Identifier Type 1.

The Fibre Channel Identification descriptor is returned only on Fibre-Channel-attached devices. The format is given in Table 16.

Table 16. Fibre Channel Identification Descriptor

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
42 : 53	Logical Unit Descriptor							

Table 16. Fibre Channel Identification Descriptor (continued)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
54 : 61	Port Identifier Descriptor							
62 : 73	Port Name (NAA) Descriptor							

Table 17. Logical Unit (NAA) Descriptor Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
42	Protocol Identifier (0)				Code Set (1h)			
43	PIV (1)	Rsvd	Association Type (00b)		Identifier Type (3h)			
44	Reserved							
45	Identifier Length (8)							
46 : 53	World Wide Node Name (WWNN)							

Table 18. Port Identifier Descriptor Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
54	Protocol Identifier (0)				Code Set (1h)			
55	PIV (1)	Rsvd	Association Type (01b)		Identifier Type (4)			
56	Reserved							
57	Identifier Length (4)							
58 : 59	Obsolete (0)							
60 : 61	Relative Target Port							

Relative Target Port is the Relative Target Port through which the command was received. Relative Target Port values are defined in Table 19 on page 23. The port identifier descriptor is only returned on Ultrium 3 drives.

Table 19. Relative Target Port Values

Value	Description
0h	Reserved
1h	Relative port 1, historically known as port A or FC port 0
2h	Relative port 2, historically known as port B or FC port 1
3h	Relative port 3, RS422 port
4h - FFFFh	Relative port 4 through 65 535

Table 20. Port Name (NAA) Descriptor Format

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
62	Protocol Identifier (0)				Code Set (1)			
63	PIV (1)	Rsvd	Association Type (01b)		Identifier Type (3)			
64	Reserved							
65	Identifier Length (8)							
66 : 73	World Wide Port Name (WWPN)							

World Wide Port Name (WWPN) is the WWPN through which the command was received. The port name descriptor is only returned on Ultrium 3 drives.

Mode Page Policy Page (87h)

The Mode Page Policy Page (see Table 21) indicates which mode page policy is in effect for each mode page supported by the logical unit.

Table 21. Mode Page Policy page

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (87h)							
2	Page Length (n-3)							
3								
mode page policy descriptor list								
4 : 7	Mode page policy descriptor (first)							
	:							
n-3 : n	Mode page policy descriptor (last)							

Each mode page policy descriptor (see Table 22) contains information describing the mode page policy for one or more mode pages or subpages. The information in the mode page policy descriptors in this page describe the mode page policy for every mode page and subpage supported by the logical unit.

Table 22. Mode Page policy descriptor

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved		Policy Page Code					
1	Policy Subpage Code							
2	MLUS	Reserved					Mode Page Policy	
3	Reserved							

The Policy Page Code field and Policy Subpage Code field indicate the mode page and subpage to which the descriptor applies.

The first mode page policy descriptor in the list contains a Policy Page Code field set to 3Fh and a Policy Subpage Code field set to FFh, indicating that the descriptor applies to all mode pages and subpages not described by other mode page policy descriptors. The Policy Page Code field is set to 3Fh and the policy Subpage Code field is set to FFh only in the first mode page policy descriptor in the list.

If the Policy Page Code field contains a value other than 3Fh or a policy Subpage Code field contains a value other than FFh, then the Policy Page Code field and the Policy Subpage Code field indicate a single mode page and a subpage to which the descriptor applies.

A Multiple Logical Units Share (MLUS) bit set to 1 indicates the mode page and subpage identified by the Policy Page Code field and policy Subpage Code field is shared by more than one logical unit. An MLUS bit set to zero indicates the logical unit maintains its own copy of the mode page and subpage identified by the Policy Page Code field and Policy Subpage Code field.

The MLUS bit is set to 1 in the mode page policy descriptor(s) that indicates the mode page policy for the

- Disconnect/Reconnect mode page (see Table 60 on page 54) and
- Fibre Channel Port Control page (see Table 65 on page 59)

The Mode Page policy field (see Table 23) indicates the mode page policy for the mode page and subpage identified by the Policy Page Code field and policy Subpage Code field. The mode page policies are described in Table 23.

Table 23. Mode page policy values

Value	Description
00b	Shared
01b	Per target port
10b	Per initiator port
11b	Per I_T nexus

Table 24. Mode Page Policy for LUN 0

Page Name	Page Code	Subpage Code	MLUS	Mode Page Policy
Read-Write Error Recovery Page	01h	00h	0	Shared (00b)
Disconnect/Reconnect Page	02h	00h	1	Per I_T nexus (11b)
Data Compression Mode Page	0Fh	00h	0	Shared (00b)
Sequential Access Device Configuration Page	10h	00h	0	Shared (00b)
Fibre Channel Logical Unit Control Page	18h	00h	0	Per I_T nexus (11b)
Fibre Channel Port Control Page	19h	00h	1	Per target port (01b)
Information Exceptions Mode Page	1Ch	00h	0	Shared (00b)

For LUN 0, this would lead to returning a Mode Page Policy Descriptor of page 3Fh and subpage FFh stating MLUS (0) and Mode Page Policy (000b - Shared). This would be followed by descriptors for the Disconnect/Reconnect Page, the Fibre Channel Logical Unit Control Page, and the Fibre Channel Port Control Page.

SCSI Ports Page (88h)

The SCSI Ports Inquiry page (see Table 25) is supported on Fibre Channel drives only. It provides a means to retrieve identification descriptors for all the SCSI ports in the drive.

Table 25. SCSI Ports Inquiry Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (88h)							
2	Reserved							
3	Page Length (n-3)							
	Identification descriptor list							
4 : n	First SCSI port identification descriptor (see Table 26 on page 26)							
	:							
n : m	Last SCSI port identification descriptor (see Table 26 on page 26)							

Each SCSI Port identification descriptor (see Table 26 on page 26) identifies a SCSI port. The SCSI port identification descriptors may be returned in any order. There will be one SCSI Port Identification Descriptor for each port in the drive.

Table 26. SCSI Port Identification Descriptor

Byte	Bit 7	6	5	4	3	2	1	0
0	Reserved (0)							
1								
2	Relative Target Port (see table yy)							
3								
4	Reserved (0)							
5								
6	Initiator Port TranscriptID Length (0)							
7								
8	Reserved (0)							
9								
10	Target Port Descriptors Length (12)							
11								
	Target port descriptor list							
12 : 23	Target port descriptor (see Table 27)							

Table 27. Target Port Descriptor Format

Byte	Bit 7	6	5	4	3	2	1	0
12	Protocol Identifier (0)				Code Set (1)			
13	PIV (1)	Rsvd	Association Type (01b)		Identifier Type (3)			
14	Reserved							
15	Identifier Length (8)							
16 : 23	World Wide Port Name (WWPN)							

Sequential-Access Device Capabilities Page (B0h)

Table 28. Sequential-Access Device Capabilities Page

Byte	Bit 7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (B0h)							
2	Page Length (2)							
3								
4	Reserved							WORM

Table 28. Sequential-Access Device Capabilities Page (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
5	Reserved							

The Write Once Read Many (WORM) bit is set to 1 on Ultrium 3 drives indicating the drive supports WORM mode operation. The WORM bit is set to 0 on Ultrium 2 drives indicating the drive does not support WORM mode operation.

Drive Component Revision Levels Pages

Table 29. Drive Component Revision Levels Pages

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Peripheral Qualifier (000b)			Peripheral Device Type (01h)				
1	Page Code (C0h)							
2	Reserved							
3	Page Length (27h)							
4 : 15	Component (CCCCCCCCCCCC)							
16 : 22	Version (RRR.VVV)							
23 : 30	Date (YYYYMMDD)							
31 : 42	Variant (XXXXXXXXXXXX)							

The Drive Component Revision Levels Pages contain details of the revisions of each of the components of the drive. This device supports only one Drive Component Revision Levels Page (Page C0h). The values returned by the device in this page are unique to the vendor and are not specified in this document.

This page contains four null-terminated ASCII strings. The Component entry has a twelve-character entry to identify the component that the revision is for. The Version entry has a seven-character version code, with a three-digit major revision number, a period, and a three-digit minor version number. The date entry has the date of the version, in year-first order. The Variant entry has a variant identifier, indicating the version of the product.

LOAD/UNLOAD

Table 30. LOAD/UNLOAD Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Bh)							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved					EOT(0)	Reten(0)	Load
5	Control							

If the Load field is set to 1 and there is a tape in the drive, it is positioned to BOM. If the Load field is set to 1 and there is no tape in the drive, Check Condition status is returned. The Sense Key is set to Not Ready (2) and the ASC/ASCQ is set to Parameter Medium Not Present (3A00).

If the Load field is set to 0, there is a tape in the drive, and medium removal prevention has not been set, then the tape is unloaded and ejected. If the Load field is set to 0, there is a tape in the drive, and medium removal prevention has been set, then Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Medium Removal Prevented (5302).

If the Load field is set to 0 and the tape is in the ejected position, the command is presented with Check Condition status and associated sense data of 2/0402 (Not Ready, Initialization Required). If the Load field is set to 0 and there is no cartridge present, the command is presented with Check Condition status and associated data of 2/3A00 (Not Ready, Medium Not Present).

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

The Retension (Reten) field is not supported and will be ignored.

The End Of Tape (EOT) field is not supported and should be set to 0. If the EOT field is set to 1, then Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

LOCATE

The LOCATE command causes the logical position on tape to be set to the value indicated by the Block Address field. The value indicates the total number of records and marks between BOM and the desired logical position. A value of 0 causes the tape to be positioned at BOM.

Table 31. LOCATE Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (2Bh)							
1	Logical Unit Number			Reserved		BT(0)	CP(0)	Immed
2	Reserved							
3 : 6	Block Address							
7	Reserved							
8	Partition (0)							
9	Control							

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

If the LOCATE command fails for anything other than Illegal Request, the logical position is not guaranteed and a READ POSITION command should be issued to determine the current logical position of the tape.

The Block Type (BT) and Change Partition (CP) fields are not supported and should be set to 0. The Partition field is not supported and will be set to 0. If the Partition field is set to anything other than 0, then Check Condition status is returned. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

LOG SELECT

The LOG SELECT command causes log data on the drive to be reset to its default value or to be set to an initiator-specific value.

Table 32. LOG SELECT Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (4Ch)							
1	Logical Unit Number			Reserved			PCR	SP(0)
2	PC		Reserved					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length							
9	Control							

If the Parameter Code Reset (PCR) field is set to 1, the Parameter List Length is 0. The action taken by the drive is specified for the values of the Page Control (PC) field as follows:

- 00b means that no action is taken and Good status is returned.
- 01b means that all resettable logs on the drive are reset to default values.
- 10b means that no action is taken and Good status is returned.
- 11b means that all resettable logs on the drive are reset to default values.

If the Parameter Code Reset (PCR) field is set to 0, the Parameter List Length is not 0. The action taken by the drive is specified for the values of the Page Control (PC) field as follows:

- 00b means that Check Condition status is returned. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).
- 01b means that data from the server is written to the indicated logs, provided that the logs are writable.
- 10b means that Check Condition status is returned. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).
- 11b means that data from the server is written to the indicated logs, provided that the logs are writable.

The Save Page (SP) field is not supported and must be set to 0.

LOG SENSE

The LOG SENSE command causes log data to be sent to the initiator.

Table 33. LOG SENSE Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (4Dh)							
1	Logical Unit Number			Reserved			PPC(0)	SP(0)
2	PC		Page Code					
3	Reserved							
4	Reserved							
5 : 6	Parameter Pointer (0)							
7 : 8	Allocation Length							
9	Control							

The log values returned are controlled by the Page Control (PC) field value as follows:

- 00b means that the maximum value for each log entry is returned.

  Note: For page 2Eh (TapeAlert) only, the PC field is ignored. Current values are always returned.
- 01b means that the current values are returned.
- 10b means that the maximum value for each log entry is returned.
- 11b means that the power-on values are returned.

The Parameter Pointer Control (PPC) must be set to 0. Returning changed parameters is not supported. The Save Page (SP) field must be set to 0. Saved pages are not supported. The Parameter Pointer will be 0.

Cartridge-specific log parameter counts are set to 0 when a cartridge has successfully loaded.

Note: The parameters in log pages should be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

Log Page Format

All log pages (except page 0) consist of a log page header, followed by a number of log parameters. The log page header has the format indicated in Table 34.

Table 34. Log Page Header Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved		Page Code					
1	Reserved							
2 : 3	Page Length							

The Page Code is a byte value that uniquely identifies what log page is being returned. The Page Length describes how many bytes are to follow for the entire log page.

Each log parameter has the format indicated in Table 35.

Table 35. Log Parameter Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 1	Parameter Code							
2	DU	DS (1)	TSD (0)	ETC (0)	TMC (0)		LBIN	LP
3	Parameter Length (n-3)							
4 : n	Parameter Bytes							

The Parameter Code is a 2-byte value that uniquely identifies the parameter within the log.

The Disable Update (DU) field is set for any parameter that the server can neither write nor reset.

The List Parameter (LP) field is 0 for parameters that are counters and 1 for parameters that are not counters.

If the LP field is 1 and the parameter is a binary parameter, then the List Binary (LBIN) field is set to 1. Otherwise it is set to 0.

The TSD, ETC and TMC fields are always 0 and the DS field is always 1.

The Parameter Length field gives the length of the Parameter Bytes field in bytes.

The Parameter Bytes field contains the actual parameter data.

Log Page 00h: Supported Log Pages

The Supported Log Pages Log Page code is 00h. The parameter list contains a series of 1-byte entries for the log pages that are supported. At least those logs described in this document must be listed. Any additional logs that are supported must also be listed.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 36. Supported Log Pages Log Page Format

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved		Page Code (00h)					
1	Reserved							
2 : 3	Page Length (n-3)							
4	Supported Log Pages (00h)							
5	Write Error Counters (02h)							
6	Read Error Counters (03h)							
7	Non-Medium Errors (06h) (Ultrium 3 devices only)							
8	Sequential Access Device Log Page (0Ch)							
9	TapeAlert (2Eh)							
10	Tape Usage Log (30h)							
11	Tape Capacity (31h)							
12	Data Compression (32h)							
13	Write Errors (33h) (Ultrium 3 devices only)							
14	Read Forward Errors (34h) (Ultrium 3 devices only)							
15	Blocks/Bytes Transferred (38h) (Ultrium 3 devices only)							
16	Host Port 0 Interface Errors (39h) (Ultrium 3 devices only)							
17	Subsystem Errors (3Dh) (Ultrium 3 devices only)							

This data can be neither reset nor written.

Log Page 02h: Write Error Counters

The Write Error Counters log is page 02h. Parameters 0 through 2 are not supported and are returned as 0. All parameter lengths are 4 bytes long, except parameter 8000 which is 8 bytes long.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 37. Write Error Log Parameters

Parameter Code (in Hex)	**Counter: Description**	**Size**
0000h	Not supported	4

Table 37. Write Error Log Parameters (continued)

Parameter Code (in Hex)	Counter: Description	Size
0001h	Not supported	4
0002h	Not supported	4
0003h	Total Corrected Write Errors: These errors are corrected by ECC and do not require error recovery procedures (ERPs). Each count represents one block in error that was corrected and written.	4
0004h	Total Write Retries:	4
0005h	Total Write Kilobytes Processed: Each count represents a kilobyte (1024 bytes) of data processed across the host interface during write-type commands. The count does not include ERP retries.	4
0006h	Total Uncorrected Write Errors: The total number of write errors that could not be corrected by ECC, no servo error was reported, and the error was not a transient error. Each count represents one block in error that was not corrected, but was recovered by ERPs and successfully written.	4
8000h	Unspecified	8
8001h	Unspecified	4

This data can be reset to 0, but cannot be written.

Log Page 03h: Read Error Counters

The Read Error Counters log is page 03h. Parameters 0 through 2 are not supported and are returned as 0. All parameter lengths are 4 bytes long, except parameter 8000 which is 8 bytes long.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

The supported fields are listed in Table 38.

Table 38. Read Error Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0000h	Not supported	4
0001h	Not supported	4
0002h	Not supported	4
0003h	Total Corrective Read Errors: These are errors that are corrected by ECC and do not require error recovery procedures (ERPs). Each count represents one block in error that was corrected and read.	4
0004h	Total Read Retries:	4

Table 38. Read Error Log Parameters (continued)

Parameter Code (in Hex)	Counter: Description	Size
0005h	Total Read Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed across the host interface during read-type commands. The count does not include ERP retries.	4
0006h	Total Uncorrected Read Errors: The total number of read errors that could not be corrected by ECC, no servo error was reported, and the error was not a transcient error. Each count represents one block in error that was not corrected, but was recovered by ERPs and successfully read.	4
8000h	Unspecified	8

This data can be reset to 0, but not written.

Log Page 06h: Non-Medium Errors (Ultrium 3 Only)

This page sums the occurrences of error events other than write or read failures. parameter codes do not discriminate among the various types of events.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 39. Non-Medium Errors log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Total Non-Medium Error Count:	4

Log Page 0Ch: Sequential Access Device Log

The Sequential Access Device Log Page is 0Ch.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 40. Sequential Access Device Log Parameters

Parameter Code (in Hex)	Counter: Description	Length
0000h	Number of data bytes received from an initiator(s) during WRITE command operations.	8
0001h	Number of data bytes written to the media as a result of WRITE command operations, not counting ECC and formatting overhead. This is also the number of data bytes after compression.	8
0002h	Number of data bytes read from the media during READ command operations, not counting ECC and formatting overhead. This is also the number of compressed data bytes read from media before decompression.	8
0003h	Number of data bytes transferred to the initiator(s) during READ command operations.	8

Table 40. Sequential Access Device Log Parameters (continued)

Parameter Code (in Hex)	Counter: Description	Length
0100h	Cleaning Required	8
8000h	Megabytes processed to tape since last cleaning (written after compression/read before decompression)	4
8001h	Lifetime load cycles of the drive	4
8002h	Lifetime cleaning cycles of the drive	4
8003h	Lifetime Power-on time (in seconds)	4

A non-zero value of the Cleaning Required parameter indicates that a condition requiring cleaning has been detected and a subsequent cleaning cycle has not been completed. The Cleaning Required parameter is persistent across hard resets and power cycles.

Log Page 2Eh: Tape Alert

The TapeAlert log page is page 2Eh. There are 64 parameters, numbered from 1 through 64 (01h through 40h). Table 41 shows the parameters that are supported for all generations of the Ultrium Tape Drive. The supported parameters are 0 in the absence of the condition that generates the flag and are set to a non-zero value when the condition occurs. All unsupported parameters are always set to 0.

All parameters are 1 byte long. Each parameter is either 0 to indicate that the corresponding condition has not occurred or non-zero to indicate that the corresponding condition has occurred. All log parameters are set to 0 when the log is read. The Log parameters are also set to 0 at power-on, on a reset condition, or by a LOG SELECT command. Specific flags may be set to 0 when corrective action has removed the condition that caused the flag to be set. For all parameters, the DU field is 1, the LP field is 0, and the LBIN field is 0.

The PC field for this page is ignored. Current values are always returned.

For a description of service actions associated with the supported parameters, refer to the *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F Setup, Operator, and Service Guide*, the *IBM Ultrium Internal Tape Drive Models T200 and T200F Setup, Operator, and Service Guide*, or the *IBM 3580 Ultrium Tape Drive Setup, Operator, and Service Guide*.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 41. TapeAlert Log Parameters

Parameter Code		Description	Set	Clear[1]	Type
In Hex	In Decimal				
01h - 02h	1 - 2	N/A			
03h	3	The operation has stopped because an error has occurred while reading or writing data which the drive cannot correct.		R	Warning
04h	4	Media can no longer be written or read, or performance is severely degraded.		R	Critical
05h	5	The tape is damaged or the drive is faulty.		R	Critical
06h	6	The drive can no longer write data to the tape.		R	Critical

Table 41. TapeAlert Log Parameters (continued)

07h	7	N/A			Warning
08h	8	The cartridge is not data-grade.		R	Warning
09h	9	The WRITE command was attempted to a write-protected tape.		R	Critical
0Ah	10	A manual or software unload was attempted when Prevent Media Removal was on.		R	Informational
0Bh	11	The tape in the drive is a cleaning cartridge.		R	Informational
0Ch	12	You attempted to load a cartridge with an unsupported tape format (for example, Ultrium 2 cartridge in Ultrium 1 drive).		R	Informational
0Dh - 0Eh	13 - 14	N/A			
0Fh	15	The memory chip failed in the cartridge.		R	Critical
10h	16	The operation has failed because the tape cartridge was manually ejected while the tape drive was actively writing or reading.		L	Warning
11h	17	Media loaded is Read-Only format.	E	R	Informational
12h	18	The tape directory on the tape cartridge has been corrupted. File search performance will be degraded. The tape directory can be rebuilt by reading all the data on the cartridge.		R	Warning
13h	19	Nearing media life		R	Informational
14h	20	Clean now		C	Critical
15h	21	Clean periodic		C	Warning
16h	22	Expired cleaning media	C	C	Critical
17h	23	Invalid cleaning tape	C	R	Critical
18h - 1Dh	24 - 29	N/A			
1Eh	30	The drive has a hardware fault that requires a reset to recover.			Critical
1Fh	31	The drive has a hardware fault that is not related to the read/write operation, or the drive requires a power cycle to recover.			Critical
20h	32	The drive has identified an interface fault.			Warning
21h	33	Eject media		U, R	Critical
22h	34	Firmware download failed			Warning
23h	35	N/A			
24h	36	The drive's temperature limits are exceeded.	S		Warning
25h	37	The drive's voltage limits are exceeded.	S		Warning
26h	38	Predictive failure of drive hardware			Critical
27h	39	Diagnostics required			Warning
28h - 32h	40 - 50	N/A			
33h	51	Tape directory invalid at unload	E	L	Warning
34h	52	Tape system area write failure	E	R	Critical
35h	53	Tape system area read failure	E	R	Critical
36h - 3Ah	54 - 58	N/A			
3Bh	59	(WORM Medium - integrity check failed) set when the drive determines that the data on tape is suspect from a WORM point of view.		L	Critical
3Ch	60	(WORM Medium - Overwrite Attempted) set when the drive rejects a Write operation because the rules for allowing WORM writes have not been met.)	E		Critical
3Dh-40h	61 - 64	N/A			

Table 41. TapeAlert Log Parameters (continued)

Legend:

TapeAlert Set/Cleared when:

N/A Not set/supported

L Load - medium is loaded

C Clean - cleaner tape is loaded

U Unload - medium is ejected

E Error - error code is posted

R Removal - medium is FULLY removed

S Sensor - sensor check

Note:

[1]All TapeAlerts are cleared on POR/Reset.

Log Page 30h: Tape Usage Log

The Tape Usage Log Page Code is 30h. These are all read directly from the tape logs.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 42. Tape Usage Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0001h	Thread Count	4
0002h	Total Data Sets Written	8
0003h	Total Write Retries	4
0004h	Total Unrecovered Write Errors	2
0005h	Total Suspended Writes	2
0006h	Total Fatal Suspended Writes	2
0007h	Total Data Sets Read	8
0008h	Total Read Retries	4
0009h	Total Unrecovered Read Errors	2
000Ah	Total Suspended Reads	2
000Bh	Total Fatal Suspended Reads	2

Log Page 31h: Tape Capacity Log

The Tape Capacity Log Page Code is 31h. Parameters 2 and 4 are not supported and are returned as 0. All parameter lengths are 4 bytes long. The supported fields are listed in Table 43.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 43. Tape Capacity Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0001h	Main Partition Remaining Capacity	4
0002h	Alternate Partition Remaining capacity	4
0003h	Main Partition Maximum Capacity	4
0004h	Alternate Partition Maximum Capacity	4

All parameters are in megabytes and assume no data compression. This data cannot be reset or written.

Note: For this command, a megabyte is equal to 1 048 576 bytes. As an example, a value of 17487h in Parameter 3 is equal to 95 367 megabytes, which is equal to 100 000 000 000 bytes.

Log Page 32h: Data Compression Log

The Data Compression Log Page Code is 32h. Parameter byte fields 0 and 1 are 2 bytes long. Parameter byte fields 2 through 9 are each 4 bytes long.

The supported fields are listed in Table 44.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 44. Data Compression Log Parameters

Parameter Code (in Hex)	Counter: Description	Size
0000h	Read Compression ratio x 100	2
0001h	Write Compression Ratio x 100	2
0002h	Megabytes transferred to server	4
0003h	Bytes transferred to server	4
0004h	Megabytes read from tape	4
0005h	Bytes read from tape	4
0006h	Megabytes transferred from server	4
0007h	Bytes transferred from server	4
0008h	Megabytes written to tape	4
0009h	Bytes written to tape	4

Parameters 2 through 9 occur as pairs that represent a large number of bytes transferred. The first 4-byte parameter represents the number of whole megabytes transferred, rounded to the nearest megabyte. The second 4-byte parameter represents the difference between this number of megabytes and the actual number of bytes. This may be a signed quantity.

This data may be reset, but may not be written.

Log Page 33h: Write Errors (Ultrium 3 Only)

This page contains detailed counters related to write operations. This page is reset when a cartridge is loaded.

Notes:

1. When multiple errors occur on a dataset, the counter that is updated is generally based on the first error detected.
2. The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 45. Write Errors log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Datasets Corrected: ECC is done by hardware. This is driven by an excessive CQs rewritten condition (TBD). Each count represents on dataset in error that was successfully corrected and written.	2
0001h	Servo Transcients: ERP action was required because of a servo detected error and the first retry was successfully in place (stop write without backhitch, i.e., servo write skip). Each count represents one dataset in error that was successfully recovered and written.	2
0002h	Data Transcients: ERP action was required because of a readback check or ECC detected error and the first retry was successfully in place (no backhitch). Each count represents one dataset in error that was successfully recovered and written.	2
0003h	Velocity Events: A velocity control problem occurred. Each count represents on occurrence, not just the count of affected datasets. Counts may include occurrences from both temporary and permanent errors.	2
0004h	Servo Acquisition Temps: A servo error (servo dropout or off-track shutdown) was detected while trying to acquire a DSS or dataset at the beginning of a write append sequence (motion). ERP action was required, and servo transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and written.	2
0005h	Data Acquisition Temps: During read-back check, the read channel failed to acquire a DSS or dataset at the beginning of a write append sequence and no servo error was reported. ERP action was required, and read/ECC transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and written.	2
0006h	Servo Temps: A servo error (servo dropout or off-track shutdown) was detected while writing data. ERP action was required, and servo transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and written.	2
0007h	Data Temps: An uncorrectable error, CRC error, instantaneous speed variation (ISV) error, or no ending burst error occurred during readback check of a dataset, and no servo error was reported. ERP action was required, and readback/ECC transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and written.	2

Table 45. Write Errors log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0008h	Total Retries: The count of the total number of ERP actions. Each count represents one occurrence, not just one time per dataset. Counts may include occurrences from both temporary and permanent errors.	2
0009h	Vendor-Reserved	2
000Ah	Vendor-Reserved (Bellcord)	2
000Bh	Servo Skip Events: The ocunt of long servo write skips, extended DSS or long spaces between datasets written. This is generally servo write skips, but may also include other write scenarios. Each count represents one occurrence, not one count per block. Counts may include occurrences from both temporary and permanent errors.	2
000Ch	Housekeeping Events: The count of write problems in the Housekeeping Dataset Region. Each count represents one occurrence, not just one time per dataset. Counts may include occurrences from both temporary and permanent errors.	2
000Dh	FID Events: The count of write problems while processing the FID. Each count represents one occurrence, not just one time per dataset. Counts may include occurrences from both temporary and permanent errors.	2
000Eh	Vendor-Reserved (Blocks Lifted)	2
000Fh	Dataset Underrun: The number of times that the drive overran the buffer processing capability and had to stop and restart during a write. Each count represents one occurrence, not just one time per write.	2
0010h	Vendor-Reserved	2
0011h	Servo Position Events: The number of servo detected positional compare discrepancies.	2

Log Page 34h: Read Forward Errors (Ultrium 3 Only)

This page contains detailed counters related to read operations. This page is reset when a cartridge is loaded.

Notes:

1. When multiple errors occur on a dataset, the counter that is updated is generally based on the first error detected. ERP counters indicate which specific ERP methods were successfully employed.
2. The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 46. Read Forward Error Counters log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Datasets Corrected: ECC is done by hardware. Each count represents one dataset in error that was successfully corrected and read.	2

Table 46. Read Forward Error Counters log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0001h	Servo Transients: ERP action was required because of a servo detected error and the first retry was successfully in place. Each count represents one dataset in error that was successfully recovered and read.	2
0002h	Data Transients: ERP action was required because of a read channel or ECC detected error and the first retry was successfully in place. Each count represents one dataset in error that was successfully recovered and read.	2
0003h	Velocity Events: A velocity control problem occurred. Each count represents one occurrence, not just the count of affected datasets. Counts may include occurrences from bot temporary and permanent errors.	2
0004h	Servo Acquisition Temps: A servo error (servo dropout or off track shutdown) was detected while trying to acquire an initial DSS or dataset. ERP action was required, and servo transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and read.	2
0005h	Data Acquisition Temps: The read channel failed to acquire an initial DSS or dataset, and no servo error was reported. ERP action was required, and read/ECC transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and read.	2
0006h	Servo Temps: A servo error (servo drop out) was detected while reading a dataset. ERP action was required, and servo transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and read.	2
0007h	Data Temps: An uncorrectable error, CRC error, or no ending burst error occurred while reading a dataset, and no servo error was reported. ERP action was required, and read/ECC transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and read.	2
0008h	Sequence Errors: A dataset number out of sequence was encountered, and no Servo or read/ECC error reported. ERP action was required, and no transient condition criteria were not met. Each count represents one dataset in error that was successfully recovered and read.	2
0009h	Vendor-Reserved (ERP Read Opposite)	2
000Ah	Vendor-Reserved (ERP Tension Adjust Hi)	2
000Bh	Vendor-Reserved (ERP Tension Adjust Lo)	2
000Ch	ERP Servo Adjust Hi: The dataset was recovered by reading with servo off-track variations. Each count represents one dataset in error that was successfully recovered and read.	2
000Dh	ERP Servo Adjust Lo: The dataset was recovered by reading with servo off-track variations. Each count represents one dataset in error that was successfully recovered and read.	2
000Eh	Vendor-Reserved (ERP Dead Reckon Nominal)	2
000Fh	Vendor-Reserved (ERP Dead Reckon Hi)	2
0010h	Vendor-Reserved (ERP Dead Reckon Lo)	2

Table 46. Read Forward Error Counters log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0011h	Vendor-Reserved (ERP Filter Coefficients)	2
0012h	Vendor-Reserved (ERP Opposite Gap)	2
0013h	Vendor-Reserved (ERP Dataflow Clock Adjust)	2
0014h	Vendor-Reserved	2
0015h	Total Retries: The count of the total number of ERP actions. Each count represents one occurrence, not just one time per dataset. Counts may include occurrences from both temporary and permanent errors.	2
0016h	Vendor-Reserved (Bellcord)	2
0017h	Housekeeping Events: The count of read problems in the Housekeeping dataset Region. Each count represents one occurrence, not just one time per dataset. Counts may include occurrences from both temporary and permanent errors.	2
0018h	Vendor-Reserved (Cartridge Init Errors)	2
0019h	Dataset Overrun: The number of times that the drive overran the buffer processing capability and had to stop and restart during a read. Each count represents one occurrence, not just one time per read.	2
001Ah	Vendor-Reserved	2
001Bh	Servo Skip Events: The count of extended DSS or long spaces between datasets read. This may include servo write skips, but may also include other write scenarios. Each count represents one occurrence, not one count per block. Counts may include occurrences from both temporary and permanent errors.	2
001Ch	Vendor-Reserved	2
001Dh	FID Events: The count of write problems while processing the FID. Each count represents one occurrence, not just one time per dataset. Counts may include occurrences from both temporary and permanent errors.	2
001Eh	Servo Position Events: The number of servo detected positional compare discrepancies.	2

Log Page 38h: Blocks/Bytes Transferred (Ultrium 3 Only)

This page is reset when a cartridge is loaded.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 47. Blocks/Bytes Transferred log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Host Write Blocks Processed: Each count represents a block processed across the host interface during a Write. The count does not include ERP retries.	4

Table 47. Blocks/Bytes Transferred log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0001h	Host Write Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed across the host interface during a Write. The count does not include ERP retries. This count may be divided by Device Write Kilobytes Processed, 0005h, to calculate an approximate write comparison ratio.	4
0002h	Host Read Blocks Processed: Each count represents a block processed across the host interface during a Read. The count does not include ERP retries.	4
0003h	Host Read Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed across the host interface during a Read. The count does not include ERP retries. This count may be divided by Device Read Kilobytes Processed, 0007h, to calculate an approximate read compression ratio.	4
0004h	Device Write Datasets Processed: Each count represents a dataset processed on the medium. The count does not include ERP retries.	4
0005h	Device Write Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed on the medium. The count does not include ERP retries or any tape formatting overhead bytes.	4
0006h	Device Read Datasets Processed: Each count represents a dataset processed from the medium. The count does not include ERP retries.	4
0007h	Device Read Kilobytes Processed: Each count represents a kilobyte (1024 bytes) processed from the medium. The count does not include ERP retries or any tape formatting overhead bytes.	4
0008h	Device Write Datasets Transferred: Each count represents a dataset processed on the medium. The count includes ERP retries.	4
0009h	Device Write Kilobytes Transferred: Each count represents a kilobyte (1024 bytes) processed on the medium. The count includes ERP retries and any tape formatting overhead bytes.	4
000Ah	Device Read Datasets Transferred: Each count represents a dataset processed from the medium. The count includes ERP retries.	4
000Bh	Device Read Kilobytes Transferred: Each count represents a kilobyte (1024 bytes) processed from the medium. The count includes ERP retries and any tape formatting overhead bytes.	4
000Ch	Nominal Capacity of Partition: The nominal capacity of the current partition (in kilobytes).	4
000Dh	Fraction of Partition Traversed: The fractional part of the current partition traversed (N/255).	1
000Eh	Nominal Capacity of Volume: The nominal capacity of the mounted volume in kilobytes. This is not sensitive to current position.	4
000Fh	Fraction of Volume Traversed: The fractional part of the mounted volume traversed (N/255).	1

Table 47. Blocks/Bytes Transferred log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0010h	Remaining Capacity of Volume: The nominal unwritten remaining capacity of the mounted volume (in kilobytes). This is not sensitive to current position.	4
0011h	Remaining Capacity of Partition: The nominal unwritten remaining capacity of the current partition (in kilobytes). This is not sensitive to current position.	4

Log Page 39h: Host Port 0 Interface Errors (Ultrium 3 Only)

This page shows the count of errors occurring on primary port 1 (while the device is active on the interface).

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 48. Host Port 0 Interface log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0000h	Host Protocol Errors: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors.	2
0007h	Host Aborts: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors.	2
0008h	Host Resets: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors.	2
0009h	Vendor-Reserved	2
000Ah	Vendor-Reserved	2
0010h	Host Recoveries: Each count represents one occurrence. Counts may include occurrences from both temporary and permanent errors. An example of host recoveries is a Sequence Retransmission Request (SRR).	4

Log Page 3Ah: Drive Control Verification (Not in Ultrium 1)

This page is for special drive control mode verification. This page is not included in the list of supported pages (page code 00h) and is not intended for general use.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Log Page 3Ch: Drive Control Statistics (Ultrium 3 Only)

This page is for special drive control mode statistics. This page is not included in the list of supported pages (page code 00h), and is not intended for general use.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Log Page 3Dh: Subsystem Statistics (Ultrium 3 Only)

The following counters all deal with subsystem statistics and errors. Most of the counters on this page are never reset. Most counters are maintained in VPD and persist across Log Selects, Log Sense, Power On Resets, and even microcode download. Lifetime values are written to VPD every eight operating hours when the drive is in a not ready state. The counters lock at maximum values.

Note: The parameters in this page should be dynamically parsed as some parameters may not be present and other parameters may be inserted.

Table 49. Subsystem Statistics log parameter codes

Parameter Code (in Hex)	Counter: Description	Size
0020h	Volume Lifetime Mounts: The total number of successful cartridge unloads performed during the lifetime of a cartridge. This field may not be updated for mounts that occur with the volume physically write protected.	4
0021h	Volume Lifetime Megabytes Written: The total amount of data in Megabytes written during the lifetime of the cartridge. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed to the medium (compressed bytes), not at the host interface. This field may not be updated during mounts that occur with the volume physically write protected.	4
0022h	Volume Lifetime Megabytes Read: The total amount of data in Megabytes read during the lifetime of the cartridge. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface. This field may not be updated during mounts taht occur with the volume physically write protected.	4
0040h	Drive Lifetime Mounts: The total number of successful cartridge unloads performed during the lifetime of the drive.	4
0041h	Drive Lifetime Megabytes Written: The total amount of data in Megabytes written during the lifetime of the drive. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed to the medium (compressed bytes), not at the host interface.	4
0042h	Drive Lifetime Megabytes Read: The total amount of data in Megabytes read during the lifetime of the drive. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface.	4
0060h	Clean Lifetime Mounts: The total number of successful cleaner cartridge operations performed during the lifetime of the drive.	4
0061h	Megabytes Written Since Clean: The total amount of data in Megabytes written since the last successful clean operation. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface.	4

Table 49. Subsystem Statistics log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0062h	Megabytes Read Since Clean: The total amount of data in Megabytes read since the last successful clean operation. On each unload, an approximate value is calculated and stored by rounding up to the nearest Megabyte. These bytes are counted as they are processed from the medium (compressed bytes), not at the host interface.	4
0063h	Mounts Since Clean: The total number of mounts performed since the last successful clean operation.	4
0080h	Library Interface Messages Received: This counter is not stored in VPD and reflects messages received for which the drive sent a positive acknowledgement since reset.	4
0081h	Library Interface Messages Transmitted: This counter is not stored in VPD and reflects messages since reset. This is incremented every time a message is sent and does not imply that an acknowledgement was received.	4
0082h	Library Interface Resets: Count of hardware reset or logical re-initializations during normal operation. This is a link reset and not a power-on reset.	4
0083h	Library Interface Buffer Errors: This includes buffer overrun or underrun conditions. This includes both H/W and S/W buffers.	4
0084h	Library Interface Sync Errors: This is incremented any time an unexpected character or set of characters occurs outside of a frame.	4
0085h	Library Interface Framing Errors: This is incremented any time there is a length problem, a bad checksum, or a missing End character.	4
0086h	Library Interface Protocol Errors: This is incremented each time an extra or unexpected acknowledgement is received, as well as every time there are consecutive messages with the same Message ID.	4
0087h	Library Interface Logical Errors: This is incremented every time a logic error is seen in the received message (for example, Message Type error).	4
0088h	Library Interface Loader Failures: This counter reflects load/unload attempts when the drive is in an incorrect state, or was otherwise unable to attempt requested loader action. This is not a failure of a load/unload that was actually attempted by the drive.	4
0089h	Library Interface NAKs Received: This is incremented every time a Negative Acknowledgement is received.	4
008Ah	Library Interface Acknowledgement Timeout: This is incremented every time a timeout occurs while waiting for an acknowledgement (for example, Link timeout).	4
008Bh	Library Interface Application Layer Timeout: This is incremented every time the drive times out waiting for an application layer Response Message.	4
0090h	Drive Lifetime Write Perms: Total number of write permanent errors that occurred on this drive.	4

Table 49. Subsystem Statistics log parameter codes (continued)

Parameter Code (in Hex)	Counter: Description	Size
0091h	Drive Lifetime Read Perms: Total number of read permanent errors that occurred on this drive.	4
0092h	Drive Lifetime Load Perms: Total number of load permanent errors that occurred on this drive.	4
0093h	Drive Lifetime Unload Perms: Total number of unload permanent errors that occurred on this drive.	4
00A0h	Drive Lifetime Write Temps: Total number of write temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
00A1h	Drive Lifetime Read Temps: Total number of read temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
00A2h	Drive Lifetime Load Temps: Total number of load temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
00A3h	Drive Lifetime Unload Temps: Total number of unload temporary errors that occurred on this drive. **Note:** This is not a count of ERP actions taken, and certain transient errors may not be included in this count.	4
0100h	Lifetime Power On Seconds: Cumulative number of seconds that the drive has been powered on. **Note:** Since this time is only periodically updated in non-volatile storage, it is possible that this time may not be entirely accurate to the full resolution of the counter.	4
0101h	Power On Seconds: Number of seconds since the drive was powered on or has undergone a hard reset condition.	4
0102h	Reset Seconds: Number of seconds since the drive has undergone a soft reset condition.	4

Log Page 3Eh: Engineering Use (Ultrium 3 Only)

This page is for engineering use only and is not included in the list of supported pages (page code 00h). As such, the counters on this page are not intended for general use.

WARNING

This page must be dynamically parsed as some parameters may not be present and other parameters may be inserted. The relative location of parameters have changed and are anticipated to continue to change.

MODE SELECT

The MODE SELECT command causes configuration data to be sent to the drive. For the format of Mode data and supported Mode pages see “MODE SENSE” on page 50. Both the 10-byte and 6-byte versions of the MODE SELECT command are supported.

Table 50. 6-Byte MODE SELECT Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (15h)							
1	Logical Unit Number			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Parameter List Length							
5	Control							

Table 51. 10-Byte MODE SELECT Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (55h)							
1	Logical Unit Number			PF	Reserved			SP
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length							
9	Control							

The Page Format (PF) field may be any value. However, the drive assumes that the format is SCSI-2. The Save Pages (SP) field is only allowed to be set to 1 when explicitly mentioned in the description of the specific mode page. The Parameter List Length field should be set to the amount of data to be sent to the drive.

The Parameter List Length field should be set to the amount of data to be sent to the drive. The Parameter List Length value is checked to ensure that it is less than or equal to the sum of the lengths of all the supported mode pages. Any command with a larger value results in a Check Condition status. The associated sense data returns with a Sense Key of Illegal Request and an ASC/ASCQ of Invalid Field in CDB (2400).

If any of the fields in the Mode pages are invalid, no parameters are altered, Check Condition status is returned, the Sense Key is set to Illegal Request, and the ASC/ASCQ is set to Invalid Field in Parameter List (2600).

MODE SENSE

The MODE SENSE command requests that the drive send its configuration data to the initiator. Pages 01h, 02h, 0Fh, 10h, and 1Ch are supported. Mode Pages 18h and 19h are supported only on Fibre Channel drives. A page 3Fh request returns all supported pages.

Both the 10-byte and the 6-byte versions of the command are supported.

Table 52. 6-Byte MODE SENSE Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Ah)							
1	Logical Unit Number			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Allocation Length							
5	Control							

Table 53. 10-Byte MODE SENSE Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (5Ah)							
1	Logical Unit Number			Reserved	DBD	Reserved		
2	PC		Page Code					
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Allocation Length							
9	Control							

If the Disable Block Descriptors (DBD) field is set to 1, then no block descriptors are returned with the mode data. If it is set to 0, then block descriptors are returned.

The type of data returned is determined by the value of the Page Control (PC) field as follows:

- 00b means the current configuration.
- 01b means the changeable bitmap (changeable = 1; unchangeable = 0).
- 10b means the default (power-on) values.
- 11b means the saved values. Because the drive does not support saved values, the default values are returned.

The PC field only affects the mode parameters within the modes pages. It does not affect the mode parameter header or the mode block descriptor. Within the mode parameters, the PC field does not affect the PS field, the Page Code, or the Additional Page Length fields. These fields will return the current values, as there is no meaning if they are changed.

The Page Code must be set to the page to be returned.

Mode Data Format

Mode data returned by a MODE SENSE command or sent with a MODE SELECT command consists of a Mode Parameter Header, an optional Mode Block Descriptor, and zero or more Mode Parameter Pages.

Table 54. Mode Data Format

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : m	Mode Parameter Header							
m + 1 : m + 8	Mode Block Descriptor							
m + 9 : n	Mode Parameter Pages							

Mode Parameter Header

Table 55. Mode Parameter Header 6-Byte Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Mode Data Length							
1	Medium Type							
2	WP	Buffered Mode			Speed (0)			
3	Block Descriptor Length							

Table 56. Mode Parameter Header 10-Byte Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 1	Mode Data Length							
2	Medium Type							
3	WP	Buffered Mode			Speed (0)			

Table 56. Mode Parameter Header 10-Byte Command (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
4	Reserved							
5	Reserved							
6 : 7	Block Descriptor Length							

In a MODE SENSE command, the Mode Data Length indicates the total amount of data available to be transferred. In a MODE SELECT command, this field is 0.

For Ultrium 1 devices, the Medium Type field is not used and must be set to 0.

For Ultrium 2 and Ultrium 3 devices, the Medium Type field on Mode Sense data is set to 00h when no media is loaded, to 18h when Ultrium 1 media is loaded, to 28h when Ultrium 2 media is loaded, and to 38h when Ultrium 3 media is loaded. On Mode Select commands, any value is allowed and ignored.

When the WORM media is loaded, the Medium Type field is logically or'ed with 0x04. Table 57 lists the Medium Type values.

Table 57. Media Type Values

Medium Loaded	Ultrium 1 drive	Ultrium 2 drive	Ultrium 3 drive
No media	0	0	0
Ultrium 1 Data	0	18h	18h
Ultrium 2 Data	N/A	28h	28h
Ultrium 3 Data	N/A	38h	38h
Ultrium 3 WORM	N/A	N/A	3Ch

The Write Protect field indicates whether the currently loaded tape is write protected in a MODE SENSE command. It is ignored in a MODE SELECT command.

Buffered Mode values dictate the behavior of the drive as follows:

- 0h (unbuffered) means that the drive will not report Good status on WRITE commands until the data blocks are actually written on the medium.
- 1h (buffered) means that the drive may report Good status on WRITE commands as soon as all the data specified in the WRITE command has been transferred to the logical unit's buffer. One or more blocks may be buffered prior to writing the blocks to the medium.
- 2h - 7h (unsupported modes) means that the drive will default to a value of 1h (buffered).

The Speed field is not used and must be set to 0.

The Block Descriptor Length is 0 if no Block Descriptor is transferred or 8 if a Block Descriptor is transferred. The Mode parameter value is stored for each initiator.

Mode Block Descriptor

Table 58. Mode Block Descriptor

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Density Code							
1 : 3	Number of Blocks (0)							
4	Reserved							
5 : 7	Block Length							

The Density Code field returns a code identifying the format of the tape currently loaded in the drive. If there is no tape loaded, the code for the highest capacity format supported by the drive is returned. See Table 119 on page 101 for details of supported density codes.

The Number of Blocks field is 0.

The Block Length field indicates the length (in bytes) of each logical block to be used in subsequent READ, WRITE and VERIFY commands when the Fixed field is set to 1. (See “READ” on page 74, “VERIFY” on page 133, and “WRITE” on page 134.) A Block Length value of 0 indicates that only variable block transfers are allowed. The default value is 0. This value must be an even number. If a transfer of odd byte-length blocks is desired, a variable length (Fixed field set to 0 in READ, VERIFY, or WRITE command) transfer must be used.

Read-Write Error Recovery Page

Table 59. Read-Write Error Recovery Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (01h)					
1	Additional Page Length (0Ah)							
2	Reserved		TB (0)	Reserved	EER(1)	PER	DTE(0)	DCR(0)
3	Read Retry Count (FFh)							
4	Reserved							
5	Reserved							
6	Reserved							
7	Reserved							
8	Write Retry Count (FFh)							
9	Reserved							
10	Reserved							
11	Reserved							

On Ultrium 1 drives, a post error (PER) field is set to 0.

On Ultrium 2 and Ultrium 3 drives, a post error (PER) field of 1 specifies that the tape drive will return Check Condition status to report recovered errors. A PER field of 0 specifies that the tape drive will not report errors that are recovered within the limits established by the error recovery parameters. If this field is 0, the disable transfer on error (DTE) field must also be set to 0.

A DTE field of 0 specifies that the tape drive will not terminate the transfer for errors that are recovered within the limits that are established by the read-write error recovery parameters. On Ultrium drives, the DTE is always set to 0.

Disconnect/Reconnect Page

Table 60. Disconnect/Reconnect Mode Page

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (02h)					
1	Additional Page Length (0Eh)							
2	Buffer Full Ratio (0)							
3	Buffer Empty Ratio (0)							
4 : 5	Bus Inactivity Limit (0)							
6 : 7	Disconnect Time Limit (0)							
8 : 9	Connect Time Limit (0)							
10 : 11	Maximum Burst Size							
12	Reserved							DTDC (0)
13	Reserved							
14	Reserved							
15	Reserved							

The Maximum Burst Size field for the SCSI parallel interface indicates (in multiples of 512 bytes) the number of bytes that the drive should attempt to send or receive between disconnects. The default is 0, which implies that the drive may send bursts of data at any size.

The Maximum Burst Size field for the Fibre Channel interface indicates the sequence size that the drive should attempt to use when transferring data. Any value is allowed and ignored. The value for the Maximum Burst Size field is stored for each initiator.

The Buffer Full Ratio and Buffer Empty Ratio fields will be 0, because buffer management is controlled by the drive.

The Bus Inactivity Limit, Disconnect Time Limit, and Connect Time limit fields are not supported and must be set to 0.

The Data Transfer Disconnect Control field is not supported and must be set to 0.

Data Compression Mode Page

Table 61. Data Compression Mode Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (0Fh)					
1	Additional Page Length (0Eh)							
2	DCE	DCC(1)	Reserved					
3	DDE(1)	RED (00b)		Reserved				
4 : 7	Compression Algorithm (1)							
8 : 11	Decompression Algorithm (1)							
12	Reserved							
13	Reserved							
14	Reserved							
15	Reserved							

A data compression enable (DCE) field of 1 indicates that data compression is determined by the state of the Select Data Compression Algorithm field of the Sequential Access Device Configuration Page (10h). The Sequential Access Device Configuration Page (10h) need not be present in the same MODE SELECT command. The drive will examine the current state of the Select Data Compression Algorithm to determine if compression is to be enabled or disabled. The default for DCE is 1. If DCE is 0, the drive uses Scheme 2 of the LTO-DC algorithm (passthrough mode).

Note: The result of this is that the only way to turn compression on is for both the DCE field of the Data Compression Mode Page (0Fh) and the Select Data Compression Algorithm field of the Sequential Access Device Configuration Page (10h) to be set to 1.

A data decompression enable (DDE) field is set to 1 to specify that data decompression is enabled.

The report exception on the decompression (RED) field is set to 00b and specifies the response to certain boundaries that the drive detects in the data on the medium. Table 62 describes those responses.

Table 62. Responses to Data Boundaries

Prior Data	Current Data	Response Sense Key (see Notes 1 and 2)
Uncompressed	Compressed unsupported algorithm	Medium Error
Uncompressed	Compressed supported algorithm	None
Compressed supported algorithm	Uncompressed	None
Compressed supported algorithm	Compressed unsupported algorithm	Medium Error
Compressed unsupported algorithm	Uncompressed	None
Compressed unsupported algorithm	Compressed supported algorithm	None
All other combinations	- -	None

Notes:

1. None in the Response Sense Key column means that no Check Condition status is returned, given the data boundary condition and the current value of the Report Exception on the Decompression (RED) field.
2. The appropriate additional sense code (ASC) is specified as follows:
   - The drive will return a Check Condition status when data is encountered on a medium (during a read operation) that the device is unable to decompress. In this table, data boundaries that are marked other than None in Response Sense Key column will generate Check Condition status with the specified sense key.
   - If the application client selects an algorithm that the drive does not support, the drive will return a Check Condition status. The Sense Key must be set to Illegal Request and the ASC must be set to Invalid Field in Parameter List. The SELECT DATA COMPRESSION ALGORITHM field in the Device Configuration mode page will be ignored if a Data Compression mode page with the DCE field set to 1 is also received by the device in the same MODE SELECT command.

No other fields are changeable.

Sequential Access Device Configuration Page

The Write Delay Time field indicates the time (in 100-ms increments) that the drive should wait with unwritten data in the buffer and no activity on the interface before forcing data to tape.

The Active Partition field will be 0 because multiple partitions are not supported.

The Change Active Format (CAF) and Active Format fields will be 0 because changing formats is not supported.

The Write Buffer Full Ratio and Read Buffer Empty Ratio fields will be 0 because buffer management is done by the drive.

The Data Buffer Recovery (DBR), Report Set Marks (RSmk), Stop On Consecutive File Marks (SOCF), Recover Buffer Order (RBO), Report Early Warning on Read (REW), and Synchronize at Early Warning fields must be set to 0 because these features are not supported.

The Automatic Velocity Control (AVC) field must be set to 0 because velocity control is managed by the drive.

The Gap Size field must be set to 0 because there is no concept of inter-block gaps in the format.

Table 63. Sequential Access Device Configuration Page

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (10h)					
1	Additional Page Length (0Eh)							
2	Reserved	CAP (0)	CAF (0)	Active Format (0)				
3	Active Partition (0)							
4	Write Buffer Full Ratio (0)							
5	Read Buffer Empty Ratio (0)							
6 : 7	Write Delay Time							
8	DBR (0)	BIS (1)	RSmk (0)	AVC (0)	SOCF (0)		RBO (0)	REW (0)
9	Gap Size (0)							
10	EOD Defined (0)			EEG (1)	SEW (0)	SWP (0)	Reserved	
11 : 13	Buffer Size at Early Warning (0)							
14	Select Data Compression Algorithm							
15	WTRE		OIR (0)	Rewind on Reset (0)		ASOCWP (0)	PERSWP (0)	PRMWP (0)

The Block Identifiers Supported (BIS) field must be set to 1 because block identifiers are supported.

The enable EOD generation (EEG) field must be set to 1 because the drive always generates EOD.

The Buffer Size at Early Warning field will be 0, as this cannot be set.

The default value for the Select Data Compression Algorithm is 1 and indicates that data compression is enabled if the state of the DCE field of the Data Compression Mode Page (0Fh) is set to 1. The Data Compression Mode Page (0Fh) need not be present in the same MODE SELECT command. The drive will examine the current state of the DCE to determine if compression is to be enabled or disabled. If Select Data Compression Algorithm is 0, the drive uses Scheme 2 of the LTO-DC algorithm (passthrough mode).

Note: The result of this is that the only way to turn compression on is for both the DCE field of the Data Compression Mode Page (0Fh) and the Select Data Compression Algorithm field of the Sequential Access Device Configuration Page (10h) to be set to 1.

The WORM Tamper Read Enable (WTRE) field is supported only on Ultrium 3 drives.

The WORM Tamper Read Enable (WTRE) field has no effect on the processing of a locate, read, space, or verify operation when the drive contains a non-WORM medium.

The WTRE field specifies how the drive responds to detection of compromised integrity of a WORM medium when processing a locate, read, space, or verify operation.

Value	Action Taken by Drive
00b	If the drive detects compromised integrity on a WORM medium, it will return CHECK CONDITION status and set the sense key to MEDIUM ERROR and the additional sense code to WORM MEDIUM - INTEGRITY CHECK. (3/300Dh). The position of the medium may have changed.
01b	Detection of compromised integrity on a WORM medium shall not affect processing of a task. **Note:** An application client should set the WTRE bit to 01b only for the recovery of data from a WORM medium where the integrity of the stored data has been compromised.
10b	If the drive detects compromised integrity on a WORM medium it will return CHECK CONDITION status and set the sense key to MEDIUM ERROR and the additional sense code to WORM MEDIUM - INTEGRITY CHECK. (3/300Dh). The position of the medium may have changed.
11b	Reserved

The drive sets the WTRE field to 10b following a unit attention condition for a not-ready-to-ready transition.

Fibre Channel Logical Unit Control Page

There is one copy of this page for each initiator. This page is defined for Fibre-Channel-attached devices only.

Table 64. Fibre Channel Logical Unit Control Page

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (18h)					
1	Page Length (06h)							
2	Reserved				Protocol Identifier (0h)			
3	Reserved							EPDC

Table 64. Fibre Channel Logical Unit Control Page (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
4 : 7	Reserved							

Enable Precise Delivery Control (EPDC), when set to 1b, enables checking of a Fibre Channel Command Reference Number and ensures that the command packets are delivered in order.

The Protocol Identifier is set to 0h, which indicates that this is for use with the FCP protocol.

Fibre Channel Port Control Page

There is one copy of this page per Fibre Channel port. This page is defined for Fibre Channel drives only.

Table 65. Fibre Channel Port Control Page

Byte	Bit							
	7	6	5	4	3	2	1	0
0	PS (0)	Reserved	Page Code (19h)					
1	Page Length							
2	Reserved							
3	DTFD (0)	PLPB (0)	DDIS (0)	DLM (0)	RHA (0)	ALWI (0)	DTIPE (0)	DTOLI (0)
4 : 5	Reserved							
6	Reserved					RR_TOV Units		
7	Resource Recovery Time Out Value (RR_TOV)							
8	Reserved						Control MCM (01b)	
9 : 10	Reserved							
11	Originator CMRs Per Port (0)							
12	Reserved							
13	Responder CMRs Per Port (0)							
14 : 15	MCM_TOV (0)							

The Page Length field is returned by Mode Sense commands and should be set by Mode Select commands on Ultrium 1 drives as 0Eh, and on Ultrium 2 and Ultrium 3 drives as 06h.

The Page Length field returns the number of remaining bytes. On Ultrium 1 drives this value is 0Eh. On Ultrium 2 and Ultrium 3 drives this value is 06h.

The Resource Recovery Time Out Value (RR_TOV) is the minimum amount of time that the drive will wait for an expected response before implicitly cleaning up the resources that are related to that initiator. This may, depending on the circumstances, implicitly log-out the initiator that stopped communicating with the drive.

Care should be taken when adjusting this value, because a value that is too small has the potential to cause resources to be discarded prior to the completion of a class 3 error recovery and to prematurely log-out an initiator. It also has the potential, when the value is set too large, to cause command timeouts for non-failing initiators in a multi-initiator environment, if one of the initiators fails.

The Protocol Identifier is set to 0h, which indicates that this is for use with the FCP protocol.

Resource Recovery Time Out Value (RR_TOV) Units can have the following values:

- 000b (no timer is specified)
- 001b (timer is specified in .001-second units)
- 011b (timer is specified in .1-second units)
- 101b (timer is specified in 10-second units)

RR_TOV Value can be between 0 and FFh.

The following conditions will round the RR_TOV. If the value is rounded, a Recovered Error, Mode Parameters Rounded Check Condition is presented.

- The value of RR_TOV that is determined by the RR_TOV Units and RR_TOV Value fields is less than the minimum supported value (RR_TOV set to Minimum Value)
- The value of RR_TOV that is determined by the RR_TOV Units and RR_TOV Value fields is greater than the maximum supported value (RR_TOV set to Maximum Value)
- The RR_TOV Units is an unsupported value (RR_TOV set to Default Value)

Note that when the RR_TOV value is returned from the drive, it may be returned using different RR_TOV Units than were used to set the value in a previous Mode Select command.

Information Exceptions Mode Page

Table 66. Information Exceptions Mode Page

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	Reserved	Page Code (1Ch)					
1	Page Length (0A)							
2	Perf (0)	Reserved			DExcpt	Test	Reserved	LogErr(0)

Table 66. Information Exceptions Mode Page (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
3	Reserved				MRIE (3)			
4 : 7	Interval Timer (0)							
8 : 11	Report Count (0)							

The Information Exceptions mode page is used to control Exception Reporting by using the TapeAlert log page.

A disable exception control (DExcpt) field of 0 indicates that reporting for failure prediction threshold exceeded will be enabled. The method for reporting the failure prediction threshold exceeded when the DExcpt field is set to 0 is determined from the MRIE field. A DExcpt field of 1 indicates that the target will disable reporting of the failure prediction threshold exceeded. The default value for DExcpt is 0.

If the Test field is set to 1, the next command will fail, the Sense Key will be set to Unit Attention, and the ASC/ASCQ will be set to Failure Prediction Threshold Exceeded - False (5DFF). If the Test field is set to 0, the next command is processed normally. The default for Test is 0.

The Perf and LogErr fields will be 0. These features are not supported.

The MRIE field must be set to 3 (Conditionally generate recovered error). This method instructs the drive to report informational exception conditions (if the reporting of recovered errors is allowed) by returning a Check Condition status. If the Test field is set to 0, the status may be returned after the informational exception condition occurs on any command for which Good status would have been returned. If the Test field is set to 1, the status will be returned on the next command that is normally capable of returning an informational exception condition when the Test field is set to 0. The Sense Key must be set to Recovered Error and the Additional Sense Code will indicate the cause of the informational exception condition. This will be Failure Prediction Threshold Exceeded (5D00) if the Test field is set to 0 (true error), and Failure Prediction Threshold Exceeded -False (5DFF) if the Test field is set to 1 (test).

The command that returns the Check Condition status for the informational exception will complete without error before any informational exception condition may be reported.

The Interval Timer and Report Count must be set to 0. These fields are not supported.

Medium Configuration Mode Page

The Medium Configuration Mode Page (see Table 67 on page 62) specifies any special considerations the drive will use when processing commands when there is

a WORM medium loaded in the drive. This page is supported only on Ultrium 3 drives. This page is returned when requested by a Mode Sense command indicating either this page or all pages (3Fh).

Table 67. Medium Configuration Mode Page

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS (0)	SPF(0)	Page Code (1Dh)					
1	Page Length (1Eh)							
2	Reserved							WORMM
3	Reserved							
4	Worm Mode Label Restrictions (01h)							
5	Worm Mode Filemark Restrictions (02h)							
6-31	Reserved							

The WORMM bit is set to 1 when the drive is operating in WORM mode. The WORMM bit is set to 0 when the drive is not operating in WORM mode. If a Mode Select command is processed that attempts to change the setting of the WORMM bit, the drive returns a Check Condition status, with the sense key set to Illegal Request, and the addition sense code set to Invalid Field In Parameter List.

The Worm Model Label Restrictions field specifies the restrictions against overwriting format labels when operating in WORM mode (see Table 68).

A series of filemarks with no interleaved logical blocks immediately preceding EOD is treated as a filemark sequence and controlled by the Worm Mode Filemarks Restrictions field.

Table 68. Worm Mode Label Restrictions field values

Worm Mode Label Restrictions	Description
00h	The drive does not allow any logical blocks to be overwritten. (Not Supported)
01h	The drive allows a tape header to be overwritten. The tape header is defined as 0, 1, or 2 logical blocks followed by nothing except 0 to *n* Filemarks and EOD. This must be overwritten from BOP.
02h	The drive allows all format labels to be overwritten. (Not Supported)
03h - FFh	Reserved

The Worm Mode Filemarks Restrictions field specifies the restrictions against overwriting a series of filemarks immediately preceding EOD when operating in WORM mode (see Table 69). This field controls only the overwriting of a series of filemarks with no interleaved logical blocks immediately preceding EOD.

Table 69. Worm Mode Filemarks Restrictions field values

Worm Mode Label Restrictions	Description
00h - 01h	Reserved
02h	The drive allows any number of filemarks immediately preceding EOD to be overwritten, except the filemark closest to BOP.

Table 69. Worm Mode Filemarks Restrictions field values (continued)

Worm Mode Label Restrictions	Description
03h	The drive allows any number of filemarks immediately preceding EOD to be overwritten. (Not Supported)
04h - FFh	Reserved

Behavior Configuration Mode Page

There is one copy of this page for the drive.

Ultrium drive support for the fields in this page vary by generation and/or code level. To discover if a field can be modified, issue a Mode Sense with a PC field of 01 to see if the field is changeable. This will also return the Page Length, which must be examined to determined the length of this page, because it is expected to increase as additional Behavior configurations are added to subsequent code levels.

Table 70. Behavior Configuration Mode Page

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	PS	Reserved	Page Code (2Fh)					
1	Page Length (*n*-1)							
2	Fence Behavior							
3	Clean Behavior							
...	Reserved for Future Use							
n								

Fence Behavior

This field defines drive behavior in situations deemed dangerous for either media or data on the media.

Description	Value
Normal Operation (default) Mid-Tape Recovery (MTR) Fence Only	00h
Panic Fence Feature Enabled	01h
Reserved	02h - FFh

Normal Operation (00h: The behavior of the drive after a Panic or Exception when in normal operation (Parameter value of 00 00 00 00h) is defined below).

When the drive comes up after a Panic or Exception and no cartridge is detected, the drive will respond to SCSI commands as follows (Steps 1 and 2 are returned in response to any check condition eligible command):

1. 6/2900 sense is returned.
2. 2/3e00 is returned during POST.
3. When POST completes, enter normal operation.

When the drive comes up and detects a cartridge, it requires Mid-Tape Recovery (MTR) and will responsd to SCSI commands as follows (Steps 1 through 5 are returned in response to any check condition eligible command):

1. 6/2900 is returned.
2. 2/3e00 is returned during POST.
3. 2/0400 is returned during Mid-Tape Recovery/Unload.
4. 2/0401 is returned during Mid_Tape Recovery/Load.
5. 6/2800 is returned after cartridge is loaded.
6. Enter into the MTR Fence State.
   - TUR commands will return GOOD status.
   - Return 5/2C00 Sense for all medium access commands.
   - Exit MTR Fence State when an explicit positioning command completes successfully (that is, Locate, Rewind, Load).

Panic Fence Feature Enabled (01h): The behavior of the drive after the Panic or Exception when the Panic Fence Feature is enabled (Parameter value of 01h) is defined below.

When the drive comes up after a Panic of Exception and no cartridge is detected, the drive will respond to SCSI commands as follows (Steps 1 and 2 are returned in response to any check condition eligible command):

1. 6/2900 sense is returned.
2. 2/3e00 is returned during POST.
3. When POST completes, enter into the Panic Fence state. In the Panic Fence state:
   - SCSI commands other than RSNS/INQ/RLUNs/Read Buffer/TUR are rejected with 5/2904 sense, indicating Panic Fence state.
   - TUR commands will return 5/2904 sense.
   - Load of a cartridge through any means is not allowed.
   - SCSI Read Buffer to read dump data is accepted at any time.
   - Once dump has been read, go to normal mode.

When the drive comes up and detects Mid-Tape Recovery (MTR), it will respond to SCSI commands as follows (steps 1 through 5 are returned in response to any check condition eligible command):

1. 6/2900 sense is returned.
2. 2/3e00 is returned during POST.
3. 2/0400 is returned during Mid-Tape Recovery/Unload.
4. 2/0401 is returend during Mid-Tape Recovery/Load.
5. 6/2800 is returned after cartridge is loaded.
6. Enter into the Panic Fence state.
   - SCSI commands other than RSNS/INQ/RLUNs/Read Buffer/TUR/Load with the load bit set to 0 are rejected with 5/2904 sense, indicating Panic Fence state.
   - TUR commands will return GOOD status while tape is loaded.
   - TUR commands will return 5/2904 sense after the tape is unloaded.
   - Unload command through SCSI/LDI/Button can be executed anytime.
   - Load of a cartridge through any means is not allowed.
   - SCSI Read Buffer to read dump data is accepted at any time.
   - Once dump has been read, if the tape is still loaded, transition to MTR Fence state. If tape is still not loaded, exit from Panic Fence state and go to normal mode.

7. MTR Fence state.
   - TUR commands will return GOOD status.
   - Return 5/2C00 Sense for all medium access commands.
   - Exit MTR Fence State when an explicit positioning command completes successfully (that is, Locate, Rewind, Load).

Clean Behavior

This field defines the behavior of the drive related to cleaning.

Description	Value
Normal Operation (default)	00h
Periodic Clean Notification Enabled	01h
Reserved	02h - FFh

Periodic Clean Notification Enabled (01h): The drive will monitor the number of write and read datasets since the last cleaning. When the number of write/read datasets exceeds the criteria, the drive will put itself in a clean notification needed state. The criteria used are subject to change, but the current criteria are listed inTable 71.

Table 71. Periodic Clean Notification Usage Criteria

Generation Drive	Datasets Processed	Approximate Equivalent Full File Passes
Ultrium 1	10,000,000	40
Ultrium 2	10,000,000	20
Ultrium 3	10,000,000	40

When entering this state, the drive sets the Drive Status Flags 1, Byte 7, Bit 6: Drive Clean Required, as defined in the LDI and the drive sets the TapeAlert flag to 21.

This drive will remain in this state until a successful cleaning cycle or a Power On Reset occurs. (For example, if another data cartridge is inserted without the driving having been cleaned, the drive will function as normal. Once the TapeAlert is reported the first time, it will be cleared following normal TapeAlert rules. The Drive Status Flags will function as defined in the LDI.)

PERSISTENT RESERVE IN

The PERSISTENT RESERVE IN command is used for reservation management to show what types of Reservations and Reservation Keys exist.

Table 72. PERSISTENT RESERVE IN Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (5Eh)							
1	Reserved			Service Action				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Allocation Length							
9	Control							

Service Action may have one of two valid values:

- 00000b (reads all registered Reservation Keys)
- 00001b (reads all current persistent reservations)

Allocation Length is set to the maximum number of bytes to be transferred.

The PERSISTENT RESERVE IN parameter data for Read Keys is defined in Table 73.

Table 73. PERSISTENT RESERVE IN Parameter Data for Read Keys

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 3	Generation							
4 : 7	Additional Length							
8 : 15	First Reservation Key							
16 : n	Additional Reservation Keys							

Generation is a counter for PERSISTENT RESERVE OUT command requests.

Additional Length is a count of the number of bytes in the Reservation Key list.

For Additional Reservation Keys, a maximum of one reservation key per initiator is supported.

The PERSISTENT RESERVE IN parameter data for Read Reservations is defined in Table 74.

Table 74. PERSISTENT RESERVE IN Parameter Data for Read Reservations

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 3	Generation							
4 : 7	Additional Length							
8 : n	Reservation Descriptors							

Generation is a counter for PERSISTENT RESERVE OUT command requests.

Additional Length is a count of the number of bytes in the Reservation Key list.

Reservation Descriptors are defined in Table 75.

The PERSISTENT RESERVE IN Read Reservations Descriptor is defined in Table 75.

Table 75. PERSISTENT RESERVE IN Read Reservations Descriptor

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 7	Reservation Key							
8 : 11	Scope-specific address (0)							
12	Reserved							
13	Scope (0h)				Type			
14 : 15	Extent Length (0)							

A Scope value of 0h indicates that the persistent reservation applies to the entire logical unit.

Type may have one of the following values:

- 3h means Exclusive Access
- 6h means Exclusive Access, Registrants only

PERSISTENT RESERVE OUT

The PERSISTENT RESERVE OUT command is used for reservation management to allow different types of Reservations and Reservation Keys to be created or removed.

Table 76. PERSISTENT RESERVE OUT Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (5Fh)							
1	Reserved			Service Action				
2	Scope (0)				Type			
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length (18h)							
9	Control							

Table 77 contains the values for Service Action field. For additional information about the descriptions of each service action code, refer to the *SCSI Primary Commands-3 (SPC-3)* manual.

Table 77. Values for Service Action Codes in PERSISTENT RESERVE OUT Command

Code	Name	Description	PERSISTENT RESERVE Generation Field Incremented
00h	REGISTER	Registers a reservation key with the device server or unregisters a reservation key.	Yes
01h	RESERVE	Creates a persistent reservation that has a specified SCOPE and TYPE.	No
02h	RELEASE	Releases the selected persistent reservation.	No
03h	CLEAR	Clears all reservation keys (for example, registrations) and all persistent reservations.	Yes
04h	PREEMPT	Preempts persistent reservations or removes registrations.	Yes
05h	PREEMPT AND ABORT	Preempts persistent reservations or removes registrations and aborts all tasks for all preempted initiator ports.	Yes
06h	REGISTER AND IGNORE EXISTING KEY	Registers a reservation key with the device server or unregisters a reservation key.	Yes
07h - 1Fh	Reserved		

The value in the Type field specifies the characteristics of the persistent reservation that is being established for all data blocks within the logical unit. Table 78 on page 70

70 defines the characteristics of the different type values. For each persistent reservation type, Table 78 lists the value of the code, its name, the type of drive support, and a description of the drive support.

Table 78 contains the values for the Type field.

Table 78. Persistent Reservation Type Codes

Code	Name	Drive Support (see Note 1)	Description of Drive Support (see Note 2)
0h		N/S	Obsolete
1h	Write Exclusive	N/S	**Reads Shared:** Any application client on any initiator port may initiate tasks that request transfers from the storage medium or cache of the logical unit to the initiator port. **Writes Exclusive:** Any task from any initiator port other than the initiator port that holds the persistent reservation that requests a transfer from the initiator port to the storage medium or cache of the logical unit will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** The initiator port that delivered the PERSISTENT RESERVE OUT command with RESERVE, PREEMPT, or PREEMPT AND ABORT service action as identified by its registered reservation key.
2h		N/S	Obsolete
3h	Exclusive Access	1,2	**Reads Exclusive:** Any task from any initiator port other than the initiator port that holds the persistent reservation that requests a transfer from the storage medium or cache of the logical unit to the initiator port will be terminated with RESERVATION CONFLICT status. **Writes Exclusive:** Any task from any initiator port other than the initiator port that holds the persistent reservation that requests a transfer from the initiator port to the storage medium or cache of the logical unit will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** The initiator port that delivered the PERSISTENT RESERVE OUT command with RESERVE, PREEMPT, or PREEMPT AND ABORT service action as identified by its registered reservation key.
4h		N/S	Obsolete
5h	Write Exclusive - Registrants Only	N/S	**Reads Shared:** Any application client on any initiator port may initiate tasks that request transfers from the storage medium or cache of the logical unit to the initiator port. **Writes Exclusive:** A task that requests a transfer to the storage medium or cache of the logical unit from an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** The initiator port that delivered the PERSISTENT RESERVE OUT command with RESERVE, PREEMPT, or PREEMPT AND ABORT service action as identified by its registered reservation key.

Table 78. Persistent Reservation Type Codes (continued)

Code	Name	Drive Support (see Note 1)	Description of Drive Support (see Note 2)
6h	Exclusive Access - Registrants Only	1,2	**Reads Exclusive:** A task that requests a transfer from the storage medium or cache of the logical unit to an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Writes Exclusive:** A task that requests a transfer to the storage medium or cache of the logical unit from an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** The initiator port that delivered the PERSISTENT RESERVE OUT command with RESERVE, PREEMPT, or PREEMPT AND ABORT service action as identified by its registered reservation key.
7h	Write Exclusive - All Registrants	N/S	**Reads Shared:** Any application client on any initiator port may initiate tasks that request transfers from the storage medium or cache of the logical unit to the initiator port. **Writes Exclusive:** A task that requests a transfer to the storage medium or cache of the logical unit from an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** Any registered initiator port as identified by a zero reservation key value.
8h	Exclusive Access - All Registrants	N/S	**Reads Exclusive:** A task that requests a transfer from the storage medium or cache of the logical unit to an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Writes Exclusive:** A task that requests a transfer to the storage medium or cache of the logical unit from an initiator port that is not currently registered with the device server will be terminated with RESERVATION CONFLICT status. **Persistent Reservation Holder:** Any registered initiator port as identified by a zero reservation key value.
9h - Fh	Reserved		

Notes:

1. Drive Support is categorized as follows:
   1 = Generation 1
   2 = Generation 2
   N/S = not supported
2. The Description of Drive Support column is divided into three categories:
   A definition of the required handling for read operations.
   A definition of the required handling for write operations.
   A definition of the persistent reservation holder (for more information, refer to the *SCSI Primary Commands-3 (SPC-3)* manual.

The PERSISTENT RESERVE OUT parameter list is defined in Table 79.

Table 79. PERSISTENT RESERVE OUT Parameter List

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 7	Reservation Key							
8 : 15	Service Action Reservation Key							
16 : 19	Scope-specific Address (0)							
20	Reserved							APTPL (0)
21	Reserved							
22 : 23	Obsolete (0)							

Any value is allowed for the Reservation Key and the Service Action Reservation Key.

The value for Activate Persist Through Power Loss (APTPL) will be 0.

PREVENT/ALLOW MEDIUM REMOVAL

The PREVENT/ALLOW MEDIUM REMOVAL command is used to prevent accidental removal of the medium while it is required by an initiator.

Table 80. PREVENT/ALLOW MEDIUM REMOVAL Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Eh)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							Prevent
5	Control							

If the Prevent field is set, then eject requests from the front panel are ignored and Unload commands give Check Condition status. The Sense Key is set to Illegal Request and the ASC/ASCQ to Medium Removal Prevented (5302).

All initiators that have prevented medium removal must enable it before the medium can be removed from the drive.

READ

The READ command causes data to be transferred from the tape medium to the initiator.

Table 81. READ Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (08h)							
1	Logical Unit Number			Reserved			SILI	Fixed
2 : 4	Transfer Length							
5	Control							

If the Fixed field is set to 0 and Transfer Length is not 0, then a single block of the length in Transfer Length is to be transferred. If the next block on tape is of this length or shorter, then it is transferred to the initiator. If the next block is longer than this length, then only the length requested is returned. A Check Condition for incorrect length is returned, and the logical position is set after the block. If the length of the block was the same as the Transfer Length field, then Good status is returned.

If the Suppress Incorrect Length Indicator (SILI) field is 1 and the Fixed field is 0, the drive will do one of the following:

- Report Check Condition status for an incorrect length condition only if the overlength condition exists and the BLOCK LENGTH field in the mode parameter block descriptor is non-zero (see clause 8.3 in the *SCSI-3 Stream Commands (SSC)*).
- Not report Check Condition status if the only error is the underlength condition, or if the only error is the overlength condition and the BLOCK LENGTH field of the mode parameters block descriptor is 0.

If the SILI field is 0 and an incorrect length block is read, Check Condition status will be returned. The ILI and VALID fields must be set to 1 in the sense data and the Additional Sense Code must be set to NO ADDITIONAL SENSE INFORMATION. Upon termination, the logical position will be after the incorrect length block (end-of-partition side). If the Fixed field is 1, the INFORMATION field must be set to the requested transfer length minus the actual number of blocks read (not including the incorrect length block). If the Fixed field is 0, the INFORMATION field must be set to the requested transfer length minus the actual block length.

If the Fixed field is set to 1, the Block Length (see “Mode Block Descriptor” on page 53) is set to 0, and the Transfer Length field is not 0, Check Condition status is returned with Illegal Field in CDB (5/2400h).

If the Fixed field is set to 1, the Transfer Length field is not 0, and the Suppress Illegal Length Indicator (SILI) field is set to 0, then a sequence of blocks of the currently configured block length is to be returned, the number of blocks being indicated in the Transfer Length field. If there is a sequence of blocks of this length on the tape, they are returned to the initiator with Good status. If a block that is

longer than the configured length is encountered before the sequence is complete, the blocks up to that block are returned, followed by the configured length from the record that was too long and Check Condition status. If a block that is shorter than the configured length is encountered before the sequence is complete, the blocks up to that block are returned, followed by all of that block and Check Condition status. The current position is set after the last block that was returned or partially returned.

If the Transfer Length field is 0, and if the Suppress Illegal Length Indicator and the Fixed field are not both set, then Good status is returned and no action is taken in the drive.

If Suppress Illegal Length Indicator (SILI) field is set and the Fixed field is set, then Check Condition status is returned. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).

READ ATTRIBUTE

The READ ATTRIBUTE command allows an application client to read attribute values from medium auxiliary memory.

Table 82. READ ATTRIBUTE Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (8Ch)							
1	Reserved (0)			Service Action				
2 : 3	Reserved							
4	Reserved							
5	Volume Number (0)							
6	Reserved							
7	Partition Number (0)							
8 : 9	First Attribute ID							
10 : 13	Allocation Length							
14	Reserved							
15	Control							

If the medium auxiliary memory is not accessible because there is no medium present, the READ ATTRIBUTE command will be terminated with a Check Condition status. The Sense Key must be set to Not Ready and the Additional Sense Code must be set to Medium Not Present (3A00h).

If the medium auxiliary memory is not accessible but the medium is present, the READ ATTRIBUTE command will be terminated with a Check Condition status. The Sense Key must be set to Medium Error and the Additional Sense Code must be set to Logical Unit Not Ready, Auxiliary Memory Not Accessible (0410h).

If the medium auxiliary memory has failed, the READ ATTRIBUTE command will be terminated with a Check Condition status. The Sense Key must be set to Medium Error and the Additional Sense Code must be set to Auxiliary Memory Read Error (1112h).

The supported Service Action codes are listed in Table 83 on page 77. The sections that follow the table give the format for each supported service action.

Table 83. Supported Service Action Codes

Code	Name	Description	Format of Returned Data
00h	Attribute Values	Return attribute values	See “Format for the Attribute Values Service Action”
01h	Attribute List	Returns a list of available attribute identifiers	See “Format for the Attribute List Service Action” on page 78
02h	Volume List	Returns a list of available Volume Numbers	See “Format for the Volume List Service Action” on page 78
03h	Partition List	Returns a list of available Partition Numbers	See “Format for the Partition List Service Action” on page 79
04h	Restricted	Not applicable	Not applicable
05h - 1Fh	Reserved	Not applicable	Not applicable

The First Attribute ID field specifies the attribute identifier of the first attribute to be returned. If the specified attribute identifier is in the unsupported or nonexistent state, the READ ATTRIBUTE command will be terminated with a Check Condition status (see clause 5.10 in the *SCSI Primary Commands-3 (SPC-3)*). The Sense Key must be set to Illegal Request and the Additional Sense Code must be set to Invalid Field in CDB.

The Allocation Length field specifies how many bytes have been allocated for the returned parameter list. If the length is not sufficient to contain the entire parameter list, the first portion of the list will be returned. This is not considered an error. If the remainder of the list is required, the application client should send a new READ ATTRIBUTE command with an allocation length large enough to contain the entire parameter list or use the First Attribute ID field to restrict the attributes that are returned.

The format of parameter data that is returned by the READ ATTRIBUTE command depends on the service action that is specified.

Format for the Attribute Values Service Action

The READ ATTRIBUTE command with Attribute Values service action returns parameter data that contains the attributes that are specified by the Partition Number, Volume Number, and First Attribute ID fields in the CDB. The returned parameter data contains the requested attributes in ascending numerical order by attribute identifier value and in the format shown in Table 84.

Table 84. Parameter Data for an Attribute Values Service Action

	Bit							
Byte	7	6	5	4	3	2	1	0
0 : 3	Available Data (n-3)							

Table 84. Parameter Data for an Attribute Values Service Action (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
4 : x	Attribute #1							
m : n	Attribute #y							

The Available Data field will contain the number of bytes of attribute information in the parameter list. If the parameter list is truncated as a result of insufficient allocation length, the content of the Available Data field is not altered. The format of the attribute is described in Table 90 on page 81.

Format for the Attribute List Service Action

The READ ATTRIBUTE command with Attribute List service action returns parameter data that contains the attribute identifiers for the attributes that are not in the unsupported state and not in the nonexistent state (for information about MAM attribute states, see Table 89 on page 80). The contents of First Attribute ID field in the CDB is ignored. The returned parameter data contains the requested attribute identifiers in ascending numerical order by attribute identifier value and in the format shown in Table 85.

Table 85. Parameter Data for an Attribute List Service Action

Byte	Bit							
	7	6	5	4	3	2	1	0
0 : 3	Available Data (n-3)							
4 : 5	Attribute ID #1							
n-1 : n	Attribute ID #y							

Format for the Volume List Service Action

The READ ATTRIBUTE command with Volume List service action returns parameter data that identifies the supported number of volumes (see Table 86 on page 79). The contents of Volume Number, Partition Number, and First Attribute ID fields in the CDB are ignored.

Table 86. Parameter Data for a Volume List Service Action

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 1	Available Data (2)							
2	First Volume Number (0)							
3	Number of Volumes Available (1)							

The Available Data field contains two.

The First Volume Number field indicates the first volume that is available and will be set to 0.

The Number of Volumes Available field indicates the number of volumes that are available and will be set to 1.

Format for the Partition List Service Action

The READ ATTRIBUTE command with Partition List service action returns parameter data that identifies the number of partitions that are supported in the specified volume number (see Table 87). The contents of the Partition Number and First Attribute ID fields in the CDB are ignored.

Table 87. Parameter Data for a Partition List Service Action

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 1	Available Data (2)							
2	First Partition Number (0)							
3	Number of Partitions Available (1)							

The Available Data field contains two.

The First Partition Number field indicates the first partition that is available on the specified volume number and is set to 0.

The Number of Partitions Available field indicates the number of partitions that are available on the specified volume number and is set to 1.

Medium Auxiliary Memory

Ultrium media includes a non-volatile memory that is referred to as medium auxiliary memory (MAM). MAM is used to store data that describes the media and its contents. The Ultrium drives support MAM with the READ ATTRIBUTE and WRITE ATTRIBUTE commands. The commands retrieve and store information as attributes in MAM. For more information, see “READ ATTRIBUTE” on page 76 and “WRITE ATTRIBUTE” on page 135.

A MAM attribute is composed of the following components:

- Attribute identifier
- Attribute format code
- Bit that indicates whether the attribute is read only.
- Attribute length that specifies the number of bytes in the attribute's value
- Value of the attribute

Table 88 lists the three types of MAM attributes.

Table 88. Types of MAM Attributes

Type of MAM Attribute	Attribute Source	Example	Readable with READ ATTRIBUTE	Writable with WRITE ATTRIBUTE
Medium	Permanently stored in the MAM during manufacture.	Media Serial Number	Yes	No
Device	Maintained by the tape drive.	Load Count	Yes	No
Host	Maintained by the application client.	Backup Date	Yes	Yes

Table 89 shows the states for the types of MAM attributes.

Table 89. States for the Types of MAM Attributes

Attribute Type	Attribute State	Description
Medium or Device	Read Only	An application server may read the contents of the attribute with the READ ATTRIBUTE command, but an attempt to clear or change the attribute by using the WRITE ATTRIBUTE command will result in the command being terminated with a Check Condition status. When the Read Only field of the MAM attribute is 1, the attribute is in the read only state. (For information about the Read Only field, see "Format of MAM Attribute.")
	Unsupported	The tape drive does not support the attribute and will not return it in response to a READ ATTRIBUTE command.
Host	Nonexistent	A host attribute does not exist in the MAM until a WRITE ATTRIBUTE command creates it.
	Read/Write	The attribute has been created by using the WRITE ATTRIBUTE command. After the attribute has been created, the contents may be altered by using subsequent WRITE ATTRIBUTE commands. A read/write attribute may be returned to the nonexistent state by using a WRITE ATTRIBUTE command with the Attribute Length set to 0. When the Read Only field of the MAM attribute is 0, the attribute is in the read/write state. (For information about the Read Only field, see "Format of MAM Attribute.")

Format of MAM Attribute

Each MAM attribute will be communicated between the application client and tape drive in the format shown in Table 90 on page 81. This format will be used in the

parameter data for the WRITE ATTRIBUTE and READ ATTRIBUTE commands. The attribute format implies nothing about the physical representation of an attribute in the MAM. For more information, see “READ ATTRIBUTE” on page 76 and “WRITE ATTRIBUTE” on page 135.

Table 90. Format of a MAM Attribute

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	(MSB)							
:	Attribute Identifier							
1								(LSB)
2	Read Only	Reserved					Format	
3	(MSB)							
:	Attribute Length (n-4)							
4								(LSB)
5	(MSB)							
:	Attribute Value							
n								(LSB)

The Attribute Identifier field contains a value that identifies the attribute. For the range of values in this field, see “Values for the Attribute Identifier Field” on page 82.

The Read Only field indicates whether the attribute is in the read only or read/write state. If the field is 1, the attribute is in the read only state; if the field is 0, the attribute is in the read/write state.

The Format field specifies the format of the data in the Attribute Value field. Table 91 describes the values and requirements for the Format field.

Table 91. Values and Requirements for the Format Field

Format	Name	Generation (see Legend)	Description
00b	Binary	1,2	The Attribute Value field will contain binary data.
01b	ASCII	1,2	The Attribute Value field will contain only graphic codes (for example, byte code values 20h through 7Eh), will be left-aligned and place any unused bytes at the highest offset in the field, and will contain 20h (for example, ASCII space) in any unused bytes.
10b	Text	1,2	The attribute contains textual data. For a description of the character set, see page 86 and Table 98 on page 86.
11b	Reserved	N/S	The Attribute Value field is reserved.

Legend:

1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)

2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)

N/S = not supported

The Attribute Length field specifies the length in bytes of the Attribute Value field. The value of the Attribute Length field depends on the attribute that is returned.

The Attribute Value field contains the current (READ ATTRIBUTE) or desired (WRITE ATTRIBUTE) value of the attribute.

Values for the Attribute Identifier Field: The values in the Attribute Identifier field are assigned according to the attribute type and whether the attribute is standard or vendor unique. Table 92 lists the range of values for the each attribute type.

Table 92. Range of Values for MAM Attribute Identifiers

Range of Attribute Identifiers	Attribute Type	Standard or Vendor Unique
0000h - 03FFh	Device	Standard
0400h - 07FFh	Medium	Standard
0800h - 0BFFh	Host	Standard
0C00h - 0FFFh	Device	Vendor Unique
1000h - 13FFh	Medium	Vendor Unique
1400h - 17FFh	Host	Vendor Unique
1800h - FFFFh	Reserved	Not applicable
Note: Ultrium drives accept and process a WRITE ATTRIBUTE command that contains standard host type attribute identifier values (for example 0800h to 0BFFh) or vendor-unique host type attribute identifier values (for example 1400h to 17FFh). Standard host type attribute identifier values may be checked for conformance to the requirements described in "Standard Host Type Attributes" on page 85. Attributes may be written as long as there is sufficient available space in MAM. The Ultrium drive supports a total of 1008 bytes of Application Specific Data available for host use. Each attribute written consumes four bytes of that space for the required attribute header.		

The sections that follow describe the standard type attributes for device, medium, and host.

Standard Device Type Attributes: Device type attributes are maintained and updated by the drive when the medium and associated MAM are present. Table 93 describes the standard device type attributes.

Table 93. Standard Device Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0000h	Remaining Capacity in Partition	8	Binary
0001h	Maximum Capacity in Partition	8	Binary
0002h	Restricted	N/A	N/A
0003h	Load Count	8	Binary
0004h	MAM Space Remaining	8	Binary
0005h - 0006h	Restricted	N/A	N/A
0007h	Initialization Count	2	Binary
0008h - 0209h	Reserved	N/A	N/A

Table 93. Standard Device Type Attributes (continued)

Attribute Identifier	Name	Attribute Length (in bytes)	Format
020Ah	Device Make/Serial Number at Last Load	40	ASCII
020Bh	Device Make/Serial Number at Load-1	40	ASCII
020Ch	Device Make/Serial Number at Load-2	40	ASCII
020Dh	Device Make/Serial Number at Load-3	40	ASCII
020Eh - 021Fh	Reserved	N/A	N/A
0220h	Total MBytes Written in Medium Life	8	Binary
0221h	Total MBytes Read in Medium Life	8	Binary
0222h	Total MBytes Written in Current/Last Load	8	Binary
0223h	Total MBytes Read in Current/Last Load	8	Binary
0224h - 033Fh	Reserved	N/A	N/A
0340h	Medium Usage History (not supported)	N/A	N/A
0341h	Partition Usage History (not supported)	N/A	N/A
0342h - 03FFh	Reserved	N/A	N/A
Note: N/A = not applicable			

Remaining Capacity in Partition and Maximum Capacity in Partition are native capacities, assuming that there is no data compression for the specified medium partition. These values are expressed in increments of 1 048 576 bytes (for example, a value of 1 means 1 048 576 bytes; a value of 2 means 2 097 152 bytes; and so forth).

Load Count indicates how many times this medium has been fully loaded. This attribute should not be reset by any action of the device server.

MAM Space Remaining indicates the space that is currently free in the medium auxiliary memory. The total MAM capacity is reported in the MAM Capacity attribute. (For a description of the MAM Capacity attribute, see page 85.) **Note:** It may not always be possible to use all of the free space that is reported.

Initialization Count indicates the number of times that a device server has logically formatted the medium. This figure is cumulative over the life of the medium and will never be reset.

The Device Vendor Identification/Product Serial Number at Last Load, Device Vendor Identification/Product Serial Number at Load-1, Device Vendor Identification/Product Serial Number at Load-2, and Device Vendor Identification/Product Serial Number at Load-3 attributes give a rolling history of the last four device servers in which the medium has been loaded. The format for

the attributes is shown in Table 94.

Table 94. Format for Device Vendor Identification/Product Serial Number Attribute, Device Vendor Identification/Product Serial Number at Load-1 Attribute, Device Vendor Identification/Product Serial Number at Load-2 Attribute, and Device Vendor Identification/Product Serial Number at Load-3 Attribute

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	(MSB)							
:	Vendor Identification							
7								(LSB)
8	(MSB)							
:	Product Serial Number							
39								(LSB)

The Vendor Identification field will be the same value that is returned in the Standard Inquiry Data.

The Product Serial Number field contains a vendor-unique serial number. If the product serial number is not available, the Product Serial Number field will contain ASCII spaces (20h).

Total MBytes Written in Medium Life and Total MBytes Read in Medium Life indicate the number of data bytes that are transferred to or from the medium surface (after any data compression has been applied) over the entire life of the medium. These values are cumulative and will never be reset. They are expressed in increments of 1 048 576 bytes (for example, a value of 1 means 1 048 576 bytes; a value of 2 means 2 097 152 bytes; and so forth).

Total MBytes Written in Current/Last Load and Total MBytes Read in Current/Last Load indicate the total number of data bytes that are transferred to or from the medium surface (after any data compression has been applied) during the current load if the medium is currently loaded, or during the last load if the medium is currently unloaded. The device server should reset these attributes to 0 when the medium is loaded. These values are expressed in increments of 1 048 576 bytes (for example, a value of 1 means 1 048 576 bytes; a value of 2 means 2 097 152 bytes; and so forth).

Standard Medium Type Attributes: Medium type attributes are hard-coded into the MAM at the time of manufacture. All supported medium type attributes have a status of read only. Table 95 describes the standard medium type attributes.

Table 95. Standard Medium Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0400h	Medium Manufacturer	8	ASCII
0401h	Medium Serial Number	32	ASCII
0402h - 0405h	Restricted	N/A	N/A
0406h	Medium Manufacture Date	8	ASCII

Table 95. Standard Medium Type Attributes (continued)

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0407h	MAM Capacity	8	Binary
0408h	Medium Type	1	Binary
0409h	Medium Type Information	2	Binary
040Ah	Numeric Medium Serial Number (not supported)	N/A	N/A
040Bh - 07FFh	Reserved	N/A	N/A
Note: N/A = not applicable			

Medium Manufacturer contains 8 bytes of ASCII data that identifies the vendor of the media.

Medium Serial Number identifies the manufacturer's serial number for the medium.

Medium Manufacture Date identifies the date of manufacture of the medium. The format is YYYYMMDD (four numeric ASCII characters for the year, followed by two numeric ASCII characters for the month, followed by two numeric ASCII characters for the day, with no intervening spaces).

MAM Capacity is the total capacity of the medium auxiliary memory (in bytes) at the time of manufacture. It does not indicate the free space of unused MAM because some of the MAM space may be reserved for device-specific use, which makes it inaccessible to the application client.

Medium Type and Medium Type Information give information about non-data media and other types of media. The Medium Type Information attribute is interpreted according to the type of medium that is indicated by the Medium Type attribute. Table 96 give the values for the Medium Type and Medium Type Information attributes.

Table 96. Values for Medium Type and Medium Type Information Attributes

Medium Type	Description	Medium Type Information
00h	Data medium	Reserved
01h	Cleaning medium	Maximum number of cleaning cycles permitted
02h - 7Fh	Reserved	Reserved
80h	Write-once medium	Reserved
81h - FFh	Reserved	Reserved

Standard Host Type Attributes: Table 97 on page 86 describes the standard host type attributes. Application clients may use the WRITE ATTRIBUTE and READ ATTRIBUTE commands to maintain the attributes shown in the table. All existing host type attributes have a status of read/write.

Table 97. Standard Host Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
0800h	Application Vendor	8	ASCII
0801h	Application Name	32	ASCII
0802h	Application Version	8	ASCII
0803h	User Medium Text Label	160	Text
0804h	Date and Time Last Written	12	ASCII
0805h	Text Localization Identifier	1	Binary
0806h	Barcode	32	ASCII
0807h	Owning Host Textual Name	80	Text
0808h	Media Pool	160	Text
0809h	Partition User Text Label (not supported)	N/A	N/A
080Ah	Load/Unload at Partition (not supported)	1	Binary
080Bh - BFFh	Reserved	N/A	N/A
Note: N/A = not applicable			

Application Vendor contains 8 bytes of ASCII data that identifies the manufacturer of the application client (for example, a class driver or backup program) that most recently sent a WRITE ATTRIBUTE command to the tape drive while this MAM was accessible.

Application Name contains the name of the application client.

Application Version contains the version of the application client.

User Medium Text Label is the user-level identifier for the medium.

Date and Time Last Written contains when the application client last wrote to the MAM. The format is `YYYYMMDDHHMM` (four numeric ASCII characters for the year, followed by two numeric ASCII characters for the month, followed by two numeric ASCII characters for the day, followed by two numeric ASCII characters between 00 and 24 for the hour, followed by two numeric ASCII characters for the minute, with no intervening spaces).

Text Localization Identifier defines the character set that is used for attributes with a Text format. Table 98 gives the values for the Text Localization Identifier attribute.

Table 98. Values for the Text Localization Identifier Attribute

Value	Meaning
00h	No code specified (ASCII)
01h	ISO/IEC 8859-1 (Europe, Latin America)
02h	ISO/IEC 8859-2 (Eastern Europe)
03h	ISO/IEC 8859-3 (Southeastern Europe, miscellaneous)
04h	ISO/IEC 8859-4 (Scandinavia/Baltic)

Table 98. Values for the Text Localization Identifier Attribute (continued)

Value	Meaning
05h	ISO/IEC 8859-5 (Cyrillic)
06h	ISO/IEC 8859-6 (Arabic)
07h	ISO/IEC 8859-7 (Greek)
08h	ISO/IEC 8859-8 (Hebrew)
09h	ISO/IEC 8859-9 (Latin 5)
0Ah	ISO/IEC 8859-10 (Latin 6)
0Bh - 7Fh	Reserved
80h	ISO/IEC 10646-1 (UCS-2BE)
81h	ISO/IEC 10646-1 (UTF-8)
82h - FFh	Reserved

Barcode is the contents of a bar code that is associated with the medium in the MAM.

Owning Host Textual Name indicates the host from which the User Medium Text label originates.

Media Pool indicates the media pool to which this medium belongs.

Vendor-Specific Medium Type Attributes: Table 99 describes the vendor-specific medium type attributes. Application clients may use Read Attribute to read the contents of the attributes shown in the table.

Table 99. Vendor-Specific Medium Type Attributes

Attribute Identifier	Name	Attribute Length (in bytes)	Format
1000h	Unique Cartridge Identity (UCI)	28	Binary

The Unique Cartridge Identity (UCI) attribute is supported only on Ultrium 3 drives. The Unique Cartridge Identity (ICU) attribute is read only. Any attempt to access it using the Write Attribute command will be rejected by the drive with a Sense Key 5 ASC/ASCQ 2400 Illegal Request, Invalid Field In CDB. If the cartridge has inconsistency between the various sources from which the components of the UCI are derived, then any command to read the UCI will be rejected with a Check Condition, and Sense Key and ASC/ASCQ of (03/1112), which is an Auxiliary Memory Read Error. This error shall also be reported if the cartridge has not been initialized.

READ BLOCK LIMITS

The READ BLOCK LIMITS command (see Table 100) requests that the READ BLOCK LIMITS data (see Table 101) be returned. The READ BLOCK LIMITS data specifies the drive's limit on block lengths.

Table 100. READ BLOCK LIMITS Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (05h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

The format of the data returned in the READ BLOCK LIMITS Descriptor is shown in Table 101.

Table 101. READ BLOCK LIMITS Descriptor

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved			Granularity (0h)				
1 : 3	Maximum Block Length Limit (FFFFFFh)							
4 : 5	Minimum Block Length Limit (0001h)							

The Granularity field specifies the supported block size granularity. For Ultrium drives this is set to 0, which indicates that the drive supports all block sizes equal to n, where n is greater than or equal to the Minimum Block Length Limit and less than or equal to the Maximum Block Length Limit.

The Maximum Block Length Limit is set to 0xFFFFFF.

The Minimum Block Length Limit is set to 1.

For READ and WRITE commands with the Fixed field set to 1, block lengths are limited to multiples of four.

The Ultrium drives support fixed-block transfers or variable-block transfers, with the block length constrained between the given limits in either transfer mode. The transfer mode is controlled by the Fixed field in the WRITE or READ commands.

READ BUFFER

The READ BUFFER command reads data from the memory on the drive and sends it to the initiator. The command is used in conjunction with the WRITE BUFFER command as a diagnostic function for testing memory in the drive and the integrity of the service delivery subsystem. The READ BUFFER command is also used for retrieving data that is specified by the value of the Buffer ID. This command does not alter the medium.

Table 102. READ BUFFER Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (3Ch)							
1	Logical Unit Number			Mode				
2	Buffer ID							
3 : 5	Buffer Offset							
6 : 8	Allocation Length							
9	Control							

The Mode field and its meaning are described in Table 103.

Table 103. Description of the Mode Field

Mode	Description	Support
00h	Combined header and data	1, 2, 3
02h	Data	1, 2, 3
03h	Descriptor	1, 2, 3
07h	Descriptor (see Note)	1, 2, 3
0Ah	Echo buffer	2, 3
0Bh	Echo buffer descriptor	2, 3

Legend:

1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)

2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)

3 = supported in IBM TotalStorage LTO Ultrium 3 Tape Drive (commonly called the Ultrium 3 tape drive)

Note: The descriptor that is returned for Mode 07h has the Buffer Capacity field reported in 64-byte increments.

The Buffer ID indicates which buffer is to be read. The Buffer IDs are shown in Table 107 on page 91.

The Buffer Offset field may be set to any address in the buffer.

If the Mode is set to 07h and the Buffer ID is 0, the descriptor that is returned is for the Main Data buffer, and the Buffer Capacity field is the number of 64-byte segments that are available.

The format of the 4-byte descriptor is shown in Table 105.

Note: The Main Data buffer capacity is larger than can be represented in the Buffer Offset field of the CDB and Buffer Capacity field of the header. To compensate for this, the Buffer Offset and Buffer Capacity fields for the Main Buffer (buffer ID = 0) are interpreted and expressed in multiples of 64 bytes (for example, a value of 1 equals 64 bytes). This interpretation is for buffer modes 00h, 01h, 02h, 03h, and 07h only.

If the Mode is set to 0Ah, data from the echo buffer is returned.

In this mode, Buffer ID and Buffer Offset fields are ignored. Prior to issuing a READ BUFFER command that uses the echo buffer, a WRITE BUFFER command that uses the echo buffer must have been successfully completed (see"WRITE BUFFER" on page 137). If not, the Read Echo Buffer terminates with a Check Condition status, the Sense Key is set to Illegal Request, and ASC/ASCQ is set to Command Sequence Error (2C00h). The Read Echo Buffer returns the same number of bytes of data as was received in the prior Write Echo Buffer from the same initiator.

If the Mode is set to 0Bh, the descriptor information of the echo buffer is returned. The format of the echo buffer descriptor is shown in Table 106 on page 91. The Echo Buffer Overwritten Supported (EBOS) is set to 1 because the drive keeps the echo buffer for each initiator.

Table 104. READ BUFFER Header

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Reserved							
1 : 3	Buffer Capacity							

Table 105. READ BUFFER Descriptor

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Offset Boundary (0h means byte boundary)							
1 : 3	Buffer Capacity							

Table 106. READ ECHO BUFFER Descriptor

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Reserved							EBOS (1)
1	Reserved							
2	Reserved			Buffer Capacity				
3	Buffer Capacity							

Table 107. Drive Buffers

Supported Buffers	ID	Offset Boundary	Ultrium Support
Main Data	00h	4	1, 2, 3
Dump Data (Read Only) (See Note)	01h	4	1, 2, 3
Test	02h	4	1, 2, 3
VPD	03h	4	1, 2, 3
Firmware	04h	4	1, 2, 3
Cartridge Memory (Read Only)	05h	4	1, 2, 3
Error Log (Read Only)	06h	4	1, 2, 3
SCSI Log (Read Only)	07h	4	1, 2, 3
Fibre Channel WWN (Read Only)	08h	4	1, 2, 3
Reserved	09h-80h	N/A	N/A
(IBM use only)	81h	N/A	N/A
(IBM use only)	83h	N/A	N/A
Reserved	84h-FFh	N/A	N/A

Legend:

1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)

2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)

3 = supported in IBM TotalStorage LTO Ultrium 3 Tape Drive (commonly called the Ultrium 3 tape drive)

N/A = not applicable

Note: When reading dump data on a Fibre Channel drive, take care to ensure that the amount of data in each transfer does not exceed the DMA settings of the HBA. The dump data currently exceeds 1 MB in size. The default DMA setting for some HBAs is 1 MB. For this reason, it is recommended that the dump data is read in a series of smaller blocks with appropriate offsets (for example, 64 K bytes).

Error Log Buffer

The error log buffer contains zero or more entries described in Table 108 on page 92.

Table 108. Error Log Buffer Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0 : 3	Time Stamp							
4	Entry Number							
5	Error Code							
6 : 7	Fsc 1st Text							
8 : 9	Fsc 1st Data							
10 : 11	Fsc 2nd Text							
12 : 13	Fsc 2nd Data							
14 : 21	Cartridge Serial Number							
22 : 27	EC Level							
28 : 31	Hardware Level							

Fibre Channel World Wide Name Buffer

This buffer contains the Fibre Channel World Wide Name values that are used by the drive on LUN 0. Table 109 on page 93 describes the Fibre Channel World Wide Name buffer.

Table 109. Fibre Channel World Wide Name Buffer

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 7	World Wide Node Name							
8 : 15	World Wide Port Name							

SCSI Log Buffer

The SCSI log buffer contains 10 entries, each of which has the format described in Table 110.

Table 110. SCSI Log Buffer Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 3	Time Stamp (seconds)							
4	Entry Number							
5	Initiator SCSI ID							
6	SCSI Status							
7	Reserved							
8 : 23	CDB							
24 : 59	Sense Data							

An Entry Number set to 0 indicates that the entry is not valid. The scheme used for setting the Entry Number is not described in this manual.

Valid entries are built for commands that are issued to LUN 0 and that get a Check Condition status for sense data that contain a Sense Key of 3 or 4.

The CDB field contains the contents of the CDB that received Check Condition status even when the check condition is a Deferred Check Condition.

READ POSITION

The READ POSITION command returns current position information to the initiator. It can be used to find the current logical position of the medium and to find information about the number of bytes or blocks in the buffer. Table 112 shows the format of the returned data.

Table 111. READ POSITION Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (34h)							
1	Logical Unit Number			Service Action (0)				
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter Length (0)							
9	Control							

Table 112. READ POSITION Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	BOP	EOP	BCU	BYCU(1)	Rsvd	BPU(0)	PERR(0)	Rsvd
1	Partition Number (0)							
2	Reserved							
3	Reserved							
4 : 7	First Block Location							
8 : 11	Last Block Location							
12	Reserved							
13 : 15	Number of blocks in buffer							
16 : 19	Number of bytes in buffer (0)							

The First Block Location specifies the block address that is associated with the current logical position. The value indicates the block address of the next data block to be transferred between the initiator and the target if a READ or WRITE command is issued.

The Last Block Location is specified by the following procedure:

1. After a WRITE, WRITE FILEMARK, or any command failed for a deferred write error, this field specifies the block address that is associated with the next block to be transferred from the buffer to the medium.
2. After a successful read type command (e.g. Read, Space, Locate, non-immediate Rewind), this field is returned as 0.

The Beginning of Partition (BOP) field is set if the Block Location fields are 0.

An end-of-partition (EOP) field of 1 specifies that the logical unit is positioned between early-warning and end-of-partition. An EOP field of 0 specifies that the current logical position is not between early-warning.

The Block Position Unknown (BPU) field is always set to 0, because the position is always known.

The Partition Number is set to 0 because partitioning is not supported.

A block count unknown (BCU) field of 1 indicates that the Number of Blocks in Buffer field does not represent the actual number of blocks in the buffer. A BCU field of 0 indicates that the Number of Blocks in Buffer field is valid.

A byte count unknown (BYCU) field of 1 indicates that the Number of Bytes in Buffer field does not represent the actual number of bytes in the buffer. This field is always set to 1.

The Number of blocks in buffer field is specified by the following procedure:

1. After WRITE, WRITE FILEMARK, or any command failed for a deferred write error, this field specifies the number of unwritten data blocks and filemarks that are still in the buffer.
2. After successful read type commands this field will always return 0.

RECEIVE DIAGNOSTIC RESULTS

The RECEIVE DIAGNOSTIC RESULTS command returns the results of diagnostic tests to the initiator. The format of the data returned is specified in “SEND DIAGNOSTIC” on page 112.

Table 113. RECEIVE DIAGNOSTIC RESULTS Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Ch)							
1	Logical Unit Number			Reserved				
2	Reserved							
3 : 4	Allocation Length							
5	Control							

RELEASE UNIT

The RELEASE UNIT command removes a reservation made by a RESERVE UNIT command. If there is an existing reservation from the same initiator with the same parameters, then that reservation is removed and Good status is returned. It is not an error to attempt to release a reservation that is not currently valid or is held by another initiator. In this case, the drive returns Good status without altering any reservation.

Table 114. 6-Byte RELEASE UNIT Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (17h)							
1	Logical Unit Number			Obsolete				
2	Obsolete							
3	Reserved							
4	Obsolete (0)							
5	Control							

Table 115. 10-Byte Release Unit Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (57h)							
1	Logical Unit Number			3rdPty (0)		LongID (0)		Reserved
2	Reserved							
3	Third Party Device ID (0)							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length (0)							
9	Control							

REPORT DENSITY SUPPORT

The REPORT DENSITY SUPPORT command returns details about the tape formats supported by the drive. The data is returned as a header and a series of descriptor blocks. If the Media field is set, then one descriptor block is returned with the data for the currently loaded tape. If the Media field is set to 0, the density support data block descriptors are returned by ascending Primary Density Code values.

Table 116. REPORT DENSITY SUPPORT Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (44h)							
1	Logical Unit Number			Reserved				Media
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Allocation Length							
9	Control							

The Allocation Length field specifies the maximum number of bytes that the device server may return.

The REPORT DENSITY SUPPORT command returns the REPORT DENSITY SUPPORT header (see Table 117 on page 100) followed by one or more density support data block descriptors (see Table 118 on page 100). The density support data block descriptors follow the density support header.

In an Ultrium 1 drive, the Ultrium 1 descriptor is always returned with the DEFLT field set to 1.

In an Ultrium 2 drive, if a medium is loaded in the drive and the Media field is set to 1, the descriptor of the loaded medium will be returned with the DEFLT field set to 1. If the Media bit is set to 0, the density support data block descriptors are returned with the Ultrium 1 descriptor followed by the Ultrium 2 descriptor. If there is no medium in the drive and the Media field is set to 0, both descriptors will have the DEFLT field set to 1. If a medium is loaded in the drive and the Media field is set to 0, the descriptor of the density of the loaded medium will be returned with the DEFLT field set to 1 and the descriptor of other density will be returned with the DEFLT bit set to 0.

In an Ultrium 3 drive, if a medium is loaded in the drive and the Media field is set to 1, the descriptor of the loaded medium will be returned with the DEFLT field set to 1. If the Media bit is set to 0, the density support data block descriptors are returned with the Ultrium 1 descriptor, followed by the Ultrium 2 descriptor, followed by the Ultrium 3 descriptor. If there is no medium in the drive and the Media field is set to 0, all descriptors will have the DEFLT field set to 1. If a

medium is loaded in the drive and the Media field is set to 0, the descriptor of the density of the loaded medium will be returned with the DEFLT field set to 1 and the descriptor of other density will be returned with the DEFLT bit set to 0.

The format of the REPORT DENSITY SUPPORT header is as follows:

Table 117. REPORT DENSITY SUPPORT Header

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 1	Available Density Descriptor Length							
2	Reserved							
3	Reserved							

The Available Density Descriptor Length gives the total amount of data that is available to be returned and does not include itself.

The header is followed by one or more REPORT DENSITY SUPPORT descriptor blocks with the format in Table 118.

Table 118. REPORT DENSITY SUPPORT Descriptor Block

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Primary Density Code							
1	Secondary Density Code							
2	WRTOK	DUP(0)	DEFLT	Reserved				
3	Reserved							
4	Reserved							
5 : 7	Bits per mm							
8 : 9	Media Width							
10 : 11	Tracks							
12 : 15	Capacity							

Table 118. REPORT DENSITY SUPPORT Descriptor Block (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
16 : 23	Assigning Organization							
24 : 31	Density Name							
32 : 51	Description							

Table 119 shows the values that are reported for the Ultrium format.

Table 119. Density Information for LTO Formats

Field	Ultrium 1	Ultrium 2	Ultrium 3
Primary density code	40h	42h	44h
Secondary density code	40h	42h	44h
Bits per mm	4880	7398	9638
Media width (in tenths of mm)	127	127	127
Tracks	384	512	704
Capacity (in 2^{20} bytes)	95,367	190,734	381,469
Assigning organization	LTO-CVE	LTO-CVE	LTO-CVE
Density name	U-18	U-28	U-316
Description	Ultrium 1/8T	Ultrium 2/8T	Ultrium 3/16T

The Write Okay (WRTOK) field is set to 0 if the drive does not support writing to this format, but does support reading it. This is always set to 1 for Ultrium 1 and Ultrium 2 drives. In Ultrium 3 drives, the WRTOK field is set to 0 when Generation 1 media is in the drive, and set to 1 when Generation 2 or Generation 3 media is in the drive.

The Duplicate (DUP) field is set to 0 for every descriptor block, indicating that each density is reported only once. A DEFLT field of 0 specifies that this density is not the default density of the drive. A DEFLT field of 1 specifies that this density is the default density.

Note: The default density of the drive will vary, depending on the currently mounted media. Multiple codes may return a DEFLT field of 1 when the Media field is 0 because more than one default is possible.

If the Media field is set to 0, the maximum values possible are reported. In Ultrium 2 drives, the Ultrium 1 descriptor is returned, followed by the Ultrium 2 descriptor. In Ultrium 3 drives, the Ultrium 1 descriptor is returned, followed by the Ultrium 2 descriptor, followed by the Ultrium 3 descriptor.

If the Media field is set to 1, the Capacity field specifies the approximate capacity of the current tape, assuming that recording occurs in this density with one partition.

If the Media field is 1 and the logical unit is not in the ready state, Check Condition status will be returned. The Sense Key must be set to Not Ready and the Additional Sense Code will specify the reason for Not Ready.

The Bits per mm field specifies the number of bits per millimeter per track as recorded on the medium. See Table 119 on page 101 for the values that are returned.

The Media Width field specifies the width of the medium that is supported by this density. See Table 119 on page 101 for the values that are returned.

The Tracks field specifies the number of data tracks that are supported on the medium by this density. See Table 119 on page 101 for the values that are returned.

If the Media field is 0, the Capacity field specifies the approximate capacity of the longest supported medium for this density. If the Media field is 1, the Capacity field specifies the approximate capacity of the current medium for this density. If the approximate capacity of the current medium is not available for the mounted medium, the longest supported medium capacity for this density is used. The capacity assumes that compression is disabled. The capacity also assumes that the media is in good condition, and that normal data and block sizes are used. This value is in units of megabytes (10^6 bytes). The drive does not guarantee that this space is actually available in all cases. See Table 119 on page 101 for the values that are returned.

The Assigning Organization field contains 8 bytes of ASCII data that identifies the organization that is responsible for the specifications that define the values in this density support data block descriptor. The data is left-aligned within this field. The ASCII value for a space (20h) is used for padding. See Table 119 on page 101 for the values that are returned.

The Density Name field contains 8 bytes of ASCII data that identifies the document (or other identifying name) that is associated with this density support data block descriptor. The data is left-aligned within this field. The ASCII value for a space (20h) is used for padding. See Table 119 on page 101 for the values that are returned.

The Description field contains 20 bytes of ASCII data that describe the density. The data is left-aligned within this field. The ASCII value for a space (20h) is used for padding. See Table 119 on page 101 for the values that are returned.

REPORT LUNs

The server uses the REPORT LUNs command to retrieve information about the Logical Units that the drive supports.

Table 120. REPORT LUNs Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (A0h)							
1	Reserved							
2	Reserved							
3	Reserved							
4	Reserved							
5	Reserved							
6 : 9	Allocation Length							
10	Reserved							
11	Control							

The allocation length is at least 16 bytes. If this is not the case, the drive returns Check Condition status, with a Sense Key of Illegal Request and an ASC/ASCQ of Invalid Field in CDB.

Table 121 shows the data that is returned:

Table 121. Logical Unit Numbers Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 : 3	LUN List Length							
4 : 7	Reserved							
8 : 15	First LUN (0000000000000000h)							
n : m	Additional LUN descriptor(s)							

The LUN List Length field contains the length in bytes of the LUN list that is available to be transferred. The LUN list length is the number of logical unit numbers in the logical unit inventory multiplied by eight. This value depends on drive configuration.

On drives not using the ADI interface that do not have the library control path feature enabled, this value is 8. On drives not using the ADI interface that have the library control path feature enabled, this value is 16 and an Additional LUN descriptor is returned with a value of 0001000000000000h.

On drives using the ADI interface, if the ENABLE bit of Logical Unit Index 01h in the Mode Page 0Eh subpage 03h is set, then an Additional LUN descriptor is returned with a value of 0001000000000000h.

On drives using the ADI interface:

- **If this command is received over a primary port**, and if the ENABLE bit of Logical Unit Index 02h in Mode Page 0Eh subpage 03h is set, then an Additional LUN descriptor is returned with a value of 0002000000000000h.
- **If this command is received over the ADT port** , then an Additional LUN descriptor is returned with a value of 0002000000000000h, regardless of the setting of the ENABLE bit of Logical Unit Index 02h in Mode Page 0Eh subpage 03h.

If the allocation length in the CDB is too small to transfer information about the entire logical unit inventory, the LUN list length value will not be adjusted to reflect the truncation.

REQUEST SENSE

Table 122. REQUEST SENSE Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (03h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Allocation Length							
5	Control							

The sense data returned is described in Table 123.

Sense Data Format

Table 123. Sense Data Format

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Valid	Sense Error Code						
1	Segment Number (0)							
2	File Mark	EOM	ILI	Reserved	Sense Key			
3 : 6	Information							
7	Additional Sense Length							
8 : 11	Command Specific Information							
12	Additional Sense Code							
13	Additional Sense Code Qualifier							
14	Field Replaceable Unit Code							
15	SKSV	C/D	Reserved		BPV	Bit Pointer		
16 : 17	SKSV (1: Field Pointer) SKSV (0: Reporting Error Fault Symptom Code)							
18 : 19	Reporting Error Flag Data							
20	Reserved (0)							

Table 123. Sense Data Format (continued)

Byte	Bit 7	6	5	4	3	2	1	0
21	Reserved				CLN	Reserved	Dump	VolValid
22 : 28	Volume Label							
29	Physical Wrap							
30 : 33	Relative LPOS Value							
34	SCSI Address							
35	RS422 Information							
36 : 39	Port Identifier (Relative Target Port Address) Reporting Sense (This is the port address of the drive port through which sense is being reported. On Fibre Channel drives, it is the Fibre Channel Fabric Port Address [e.g., 011E13 or 000026] with byte 36 being reserved. On SCSI, bytes 36 through 38 are reserved, and byte 39 is set to the port's SCSI address [i.e., byte 39 = byte 34].)							
40	Tape Directory Valid	Reserved	Reserved	Reserved	Reserved	Relative Tgt Port Reporting Sense 0: Reserved 1: Relative Tgt Port 1 (Port 0) 2: Relative Tgt Port 2 (Port 1) 3: Relative Tgt Port 3 (Library Port)		
41	Host Command (SCSI Opcode)							
42	Density Type 0: No media present 1: Gen1 (384 track) 2: Gen2 (512 track) 3: Gen3 (704 track)				Media Type (Vendor Reserved)			
43	Volume Label Cartridge Type							
44								
45 : 48	Logical Block Number (Current LBA that would be reported in Read Position command)							
49 : 52	Dataset Number							
53	1st Error FSC							
54								

Table 123. Sense Data Format (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
55 56	1st Error Flag Data							
57 58	2nd Error FSC							
59 60	2nd Error Flag Data							
61 62	Next-to-Last Error FSC							
63 64	Next-to-Last Error Flag Data							
65 66	Last Error FSC							
67 68	Last Error Flag Data							
69	LPOS Region							
70 : 85	ERP Summary Information							
86 : 89	Product Revision Level: YMDV (as defined in Standard Inquiry; this is also known as the Code Level)							
90 : 95	Reserved (0)							

The Valid field is set if the Information field contains valid information.

The descriptions that follow serve only as an overview of sense reporting in the tape drive. This tape drive conforms to all sense field reporting, as specified in the *SCSI Primary Commands-2 (SPC-2)*.

The Error Code field is set to 70h to indicate a current error that is associated with the most recently received command. It is set to 71h to indicate a deferred error that is not associated with the current command.

The segment number is 0, because the COPY, COMPARE, and COPY and VERIFY commands are not supported.

The File Mark field is set if a SPACE, READ, or VERIFY command did not complete because a file mark was read.

The End of Medium (EOM) field is set if a WRITE or WRITE FILE MARKS command completed in the early warning area. Spacing into BOM also causes this field to be set. It is also set on an attempt to read or space past EOD or if an attempt is made to space into Beginning of Media.

The Illegal Length Indicator (ILI) field is set if a READ or VERIFY ended because a block was read from tape that did not have the block length requested in the command.

For values of the Sense Key field see Chapter 6, "Sense Keys and Additional Sense," on page 147.

The Information Bytes are only valid if the Valid field is set. This occurs only for current errors and not for deferred errors. See the specific command for details about when Information Bytes are valid.

The Additional Sense Length is set to *n*-7, and is at least 10. When the sense data is associated with an Illegal Length read, the Additional Sense Length may be 10. In Generation 1 and Generation 2 drives, *n* can be as large as 35. In Generation 3 drives, *n* can be as large as 95. While this length in Generation 3 drives is not anticipated to change, it is recommended that the Additional Sense Length be used to parse that data.

The Command Specific Information is set to 0, because no supported commands define a use for this field.

For supported Additional Sense Codes and Additional Sense Code Qualifiers, see Chapter 6, "Sense Keys and Additional Sense," on page 147.

The Field Replaceable Unit field is set to 0 or to a non-zero, vendor-specific code that indicates the part of the drive that is suspected of causing the failure.

The only Sense Key-specific data supported is for Illegal Request (5h). For this sense key, the Sense Key Specific Valid field is set and the following fields may be set:

- The Command/Data (C/D) field is set to 1 if the illegal parameter was detected in the Command Descriptor Block, and is set to 0 if it was detected in the Data phase.
- If a bit within a byte was invalid, the Bit Pointer Valid (BPV) field is set and the Bit Pointer field is set to indicate which bit was in error.
- The Field Pointer is set to indicate which byte was in error.

The Clean (CLN) field is set if the drive needs cleaning, and is otherwise set to 0.

In a Low Performance drive, the LowPerf bit is set to 1. In a normal, non-performance limited drive, the LowPerf bit is set to 0.

The Dump field indicates that the drive has a Dump available. The field is used to indicate when it is appropriate to read a dump.

The Volume Label Fields Valid (VolValid) field is set if the Volume Label being reported is valid.

If a cartridge is loaded in the drive and the Volume Label Fields Valid is set, the Volume Label field reports the seven characters from the left of the volume label

from the CM Mechanism Related Data page (if one exists), or it reports the seven characters from the left of the volume label from the host bar code field in the CM (if it exists), or it reports all spaces (ASCII 20h).

The Current Wrap reports the physical wrap of the tape. The least significant bit reflects the current physical direction. A 0 means the current direction is away from physical beginning of tape. A 1 means the current direction is towards physical beginning of tape.

Relative LPOS reports the current physical position on tape.

SCSI Address reports the SCSI Bus Address for the drive. Values returned range from 00h to 0Fh.

The RS422 Information field may contain a value passed across the RS-422 serial interface by, for example, a tape library, if the library vendor chooses to send such a value. The value passed from across the RS-422 interface is reported persistently until a different value is sent, at which time the new value is reported persistently.

The Volume Label Cartridge Type is defined by Table 124.

Table 124. Volume Label Cartridge Type

Definition	Native Capacity	Volume Label Cartridge Type
Ultrium 1 Type A	100 GB	L1
Ultrium 1 Type B	50 GB	LA
Ultrium 1 Type C	30 GB	LB
Ultrium 1 Type D	10 GB	LC
Ultrium 2 Type A	200 GB	L2
Ultrium 3 Type A	400 GB	L3
Ultrium 3 WORM A	400 GB WORM	LT

RESERVE UNIT

The RESERVE UNIT command creates a reservation for the drive. Third-party reserves are not supported.

Table 125. 6-Byte RESERVE UNIT Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (16h)							
1	Logical Unit Number			Obsolete (00h)				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

Table 126. 10-Byte Reserve Unit Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (56h)							
1	Logical Unit Number			3rdPty(0)	Reserved		LongID (0)	Reserved
2	Reserved							
3	Third Party Device ID (0)							
4	Reserved							
5	Reserved							
6	Reserved							
7 : 8	Parameter List Length (0)							
9	Control							

REWIND

The REWIND command causes the logical position to be set to BOM.

Table 127. REWIND Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (01h)							
1	Logical Unit Number			Reserved				Immed
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

If the Immediate (Immed) field is set to 1, then the drive validates the command and waits for any previous command from any server to complete, including any immediate commands that are currently being processed. It also waits for any buffered data to be flushed to tape. It then reports a deferred error for any preceding command or buffered data, if appropriate. If there is no deferred error, the drive reports Good status and initiates the command. If the Immediate (Immed) field is set to 0, status is not returned until after the command has completed.

SEND DIAGNOSTIC

Table 128. SEND DIAGNOSTIC Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (1Dh)							
1	Self-Test Code (000b)			PF	Reserved	SelfTest	DevOfL	UnitOfL
2	Reserved							
3 : 4	Parameter List Length							
5	Control							

The SEND DIAGNOSTIC command requests the drive to perform diagnostic operations. When the SelfTest field is 0 and the Self-Test Code field contains 000b, this command is usually followed by a RECEIVE DIAGNOSTIC RESULTS command.

Table 129 lists the supported diagnostics.

Table 129. Supported Diagnostics

Name	Diagnostic ID	Go To Page...
Self-Test	N/A	117
Post A Self Test Diagnostic	0100h	118
Post B Performance Diagnostic	0101h	118
Post C Media Test Diagnostic	0102h	120
Post D Head Test Diagnostic	0103h	121
Force Dump	0160h	121
Write Dump to Cartridge	0161h	122
Set Traps	0190h	123
Remove Traps	0191h	125
Reset Drive	2002h	126
Note: N/A = not applicable		

SIM Data Structure

The following data structure is used in several of the diagnostics. Its purpose is to give detailed error information about drive problems:

Table 130. SIM Data Structure

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (31h)							
1	Reserved							
2 : 3	Page Length (0044h)							
4 : 5	Parameter Code (0000h)							
6	Parameter Control (061h)							
7	Parameter Length (040h)							
8	Indicator (01h)							
9 : 15	Reserved							
16 : 19	Microcode Level							
20 : 21	SIM Message Code							
22 : 23	Reserved							
24	Exception Message							
25	Service Message							
26	Severity Code							
27	Reserved							
28 : 29	Exception Data (00h)							

Table 130. SIM Data Structure (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
30 : 33	Error Code							
34 : 37	First FSC							
38 : 41	Last FSC							
42 : 45	Product ID (8000h)							
46 : 48	Vendor ID “IBM”							
49 : 50	Plant of Manufacture							
51	Product ID3 ’-’							
52 : 63	Serial Number							
64 : 71	Device Type//Dev SIM_MESSAGE_TYPE							

The SIM Message Code may be one of six values:

- ’00’=No Message
- ’41’=Device Degraded
- ’42’=Device Hardware Failure
- ’43’=Service Circuit Failed
- ’55’=Drive Needs Cleaning
- ’57’=Drive Has Been Cleaned

The Exception Message may be one of eight values:

- ’1’=Effect of Failure is Unknown

- '2'=Device Exception No Performance Impact
- '3'=Exception on SCSI Interface xx
- '4'=Device Exception on Operator Panel
- '5'=Device Exception on Tape Path
- '6'=Device Exception in Drive
- '7'=Cleaning Required
- '8'=Cleaning Done

The Service Message may be one of four values:
- '1'=Repair Impact is Unknown
- '7'=Repair will Disable Access to Device Servo
- '9'=Clean Device
- 'A'=Device Cleaned

The Severity Code may be one of four values:
- '0'=Service
- '1'=Moderate
- '2'=Serious
- '3'=Acute

MIM Data Structure

The following data structure is used in several of the diagnostics. Its purpose is to give detailed error information about media problems:

Table 131. MIM Data Structure

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (31h)							
1	Reserved							
2 : 3	Page Length (0044h)							
4 : 5	Parameter Code (0000h)							
6	Parameter Control (061h)							
7	Parameter Length (040h)							
8	Indicator (02h)							
9 : 15	Reserved							

Table 131. MIM Data Structure (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
16 : 19	Engineering Data Microcode Level							
20 : 21	MIM Message Code							
22 : 23	SARS Data							
24	Exception Message							
25	Reserved							
26	Severity Code							
27 : 29	Reserved							
30 : 33	Error Code							
34 : 39	Volume ID Volume Serial Number							
40	Volume ID Flag							
41	Reserved							
42 : 45	Product ID (8000h)							
46 : 48	Vendor ID “IBM”							
49 : 50	Plant of Manufacture							
51	Product ID3 ’-’							

Table 131. MIM Data Structure (continued)

Byte	Bit							
	7	6	5	4	3	2	1	0
52 : 63	Serial Number							
64 : 71	Device Type							

The MIM Message Code may be one of four values:

- '00'=No Message
- '60'=Bad Media Read Only Permitted
- '61'=Rewrite Media if Possible
- '72'=Replace Cleaning Cartridge

The Exception Message may be one of four values:

- '2'=Data Degraded
- '4'=Medium Degraded
- '6'=CM Error
- '7'=Medium Exception

The Severity Code may be one of four values:

- '0'=Service
- '1'=Moderate - Temporary Read/Write Errors
- '2'=Serious - Permanent Read/Write Errors
- '3'=Acute - CM Error

The Volume ID Flag may be one of four values:

- '0'=VOLID not valid
- '1'=VOLID valid - obtained from tape (CM)
- '3'=VOLID valid - obtained from cartridge label (server data)
- '5'=VOLID valid - obtained from cartridge level (library)

Self-Test

For the Self-Test Diagnostic, the CDB values must be set as follows:

- PF - Any value allowed and ignored
- SelfTest - 1
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0000h

Receive Diagnostics Results: There are no diagnostic results for the Self-Test diagnostic.

Post A Self Test Diagnostic

Table 132. Post A Self Test Send Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0100h)							
6	Flags (0000000b)							Cartridge Required (bx)
7	Reserved							

Table 133. Post A Self Test Receive Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004Dh)							
4 : 5	Diagnostic ID (0100h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Post B Performance Diagnostic

The Performance Diagnostic performs a test to determine how well the tape drive writes data. If the percentage degradation exceeds the threshold, the Send Diagnostic command will return a Check Condition. The Sense Key will be set to 1h and the ASC/ASCQ set to 0000h. The FSC field of sense data will be set to

52E5, if the degradation is in the forward direction, or 52E6, if the degradation was in the backward direction. The Flag field of the sense data will be set to the percentage. TapeAlert2 (Write Warning) will be set and the SCD will display the character 'A.' The Receive Diagnostic command will return SIM data related to the failure.

Table 134. Post B Performance Send Diagnostic Parameter Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0101h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

Table 135. Post B Performance Receive Diagnostic Parameter Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004Dh)							
4 : 5	Diagnostic ID (0101h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Post C Media Test Diagnostic

Table 136. Post C Media Test Send Diagnostic Parameter Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0102h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

Table 137. Post C Media Test Receive Diagnostic Parameter Data

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (004Dh)							
4 : 5	Diagnostic ID (0102h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Post D Head Test Diagnostic

Table 138. Post D Head Test Send Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0103h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

Table 139. Post D Head Test Receive Diagnostic Parameter Data

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (004Dh)							
4 : 5	Diagnostic ID (0103h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Force Dump

The Force Dump Diagnostic causes the drive to capture into a reserved space in memory a log of data that is used to assist field and development engineers in determining the root cause of drive behavior. This log is called a drive dump. This

diagnostic copies the dump to memory, but does not save it for later use. The save operation must be done by using a READ BUFFER command or a Write Dump To Cartridge Diagnostic.

Note: Because forcing a drive dump will overwrite any previously stored dump, before forcing the dump it may be desirable to check the Dump field of the sense data to determine if a drive dump exists.

For the Force Dump Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0008h

Table 140 shows the parameter data to be sent with the Force Dump diagnostic.

Table 140. Force Dump Diagnostic Parameter Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0160h)							
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							

Receive Diagnostics Results: There are no diagnostic results for the Force Dump diagnostic.

Write Dump To Cartridge

The Write Dump To Cartridge Send Diagnostic causes the drive to write a dump from memory to the cartridge that is loaded in the drive. The dump might exist because of a previous Force Dump diagnostic command or it might exist because of other scenarios where the drive code automatically creates a dump. To determine if a drive dump exists before forcing a dump, the application client can look at the Dump field of the sense data.

Table 141. Write Dump to Cartridge Send Diagnostic Parameter Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							

Table 141. Write Dump to Cartridge Send Diagnostic Parameter Data (continued)

Byte	Bit 7	6	5	4	3	2	1	0
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (0161h)							
6	Flags (0000000b)							Cartridge Required (1b)
7	Reserved							

The Write Dump To Cartridge Receive Diagnostic returns information about the attempted Write Dump To Cartridge Send Diagnostic.

Table 142. Write Dump to Cartridge Receive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (004Dh)							
4 : 5	Diagnostic ID (0161h)							
6	Flags							
7	Reserved							
8	Flags (00000b)					Diag. Blocked	SIM/MIM Present	Error
9 : 80	SIM/MIM Message or All Zeros							

Set Traps

The Set Traps diagnostic is used to cause the drive to force a Panic when the specified Fault Symptom Code (FSC) is created in the drive. A Panic will cause the drive to capture a drive dump, then reboot. The drive dump will be available for retrieval after the reboot.

In Ultrium 2 and Ultrium 3 drives, a list of traps can be created. When the list is full, the next trap that is set will automatically clear the least recently set trap. Currently, the maximum number of traps that can be set is 10, but may be modified at any time.

In Ultrium 1 drives only one trap is allowed to be set at a time.

For the Set Traps Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 000Ah

Table 143 shows the parameter data to be sent with the Set Traps diagnostic.

Table 143. Set Traps Diagnostic Parameter Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0006h)							
4 : 5	Diagnostic ID (0190h)							
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							
8 : 9	Fault Symptom Code							

Receive Diagnostics Results: There are no diagnostic results for the Set Traps diagnostic.

Remove Traps

The Remove Traps diagnostic is used to remove a trap that has been previously set by a Set Traps diagnostic. The Fault Symptom Code (FSC) that is specified is cleared from the trap list.

For the Remove Traps Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - Any value allowed and ignored
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 000Ah

Table 144 shows the parameter data to be sent with the Remove Traps diagnostic.

If all that is desired is to inspect which Traps have been set, sending down Remove Traps with the Fault Symptom Code set to 0000h will set up diagnostic results that show which traps are currently set without changing the state of any traps.

Table 144. Remove Traps Diagnostic Parameter Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0006h)							
4 : 5	Diagnostic ID (0191h)							
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							
8 : 9	Fault Symptom Code							

Receive Diagnostics Results - Table 145 shows the diagnostic results data returned for the Remove Traps diagnostic.

Table 145. Reset Drive Diagnostic Results Data

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Page Code (80h)							
1	Reserved							

Table 145. Reset Drive Diagnostic Results Data (continued)

Byte	Bit 7	6	5	4	3	2	1	0
2 : 3	Page Length (*n* - 4)							
4 : 5	Diagnostic ID (0191h)							
6	Flags (0)							
7	Reserved							
8	Reserved					Diag Blocked	Reserved	Error
9-10 : (*n*-1)-*n*	First Fault Symptom Code with Trap Still Set Last Fault Symptom Code with Trap Still Set							

Reset Drive

The Reset Drive diagnostic causes the drive to reboot. All data in the drive is lost.

For the Reset Drive Diagnostic, the CDB values should be set as follows:

- PF - 1
- SelfTest - 0
- DevOfl - 1
- UnitOfl - Any value allowed and ignored
- Parameter List Length - 0008h

Table 146 shows the parameter data to be sent with the Reset Drive.

Table 146. Reset Drive Diagnostic Parameter Data

Byte	Bit 7	6	5	4	3	2	1	0
0	Page Code (80h)							
1	Reserved							
2 : 3	Page Length (0004h)							
4 : 5	Diagnostic ID (2002h)							

Table 146. Reset Drive Diagnostic Parameter Data (continued)

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
6	Flags (0000000b)							Cartridge Required (0)
7	Reserved							

Receive Diagnostics Results: There are no diagnostic results for the Reset Drive diagnostic.

SET CAPACITY

The SET CAPACITY command is supported in Ultrium 2 and Ultrium 3 drives only and sets the available medium for the currently mounted tape to a proportion of the total capacity of that tape. Any excess space will be unavailable on the tape after successful completion of this command until changed by a new SET CAPACITY command. This change will persist through power cycles, logical unit resets, and the unloading or reloading of the tape.

Table 147. SET CAPACITY Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (0Bh)							
1	Reserved							Immed
2	Reserved							
3	(MSB)							
:	Capacity Proportion Value							
4								(LSB)
5	Control							

If the tape drive does not contain a tape, then the command will be terminated with Check Condition status. The Sense Key must be set to Not Ready, and the Additional Sense Code must be set to Medium Not Present.

The SET CAPACITY command will be accepted only when the tape is at beginning-of-tape (BOT). If the tape is logically at any other position, the command will be rejected with Check Condition status. The Sense Key will be Illegal Request, and the Additional Sense Code set to Position Past Beginning Of Medium (5/3B0Ch).

A valid SET CAPACITY command will cause all data on the entire physical tape to be lost.

Buffered write data may be discarded by the tape drive upon successful validation of the SET CAPACITY command.

An Immediate (Immed) field of 0 specifies that the device server will not return status until the set capacity operation has completed. An Immed field of 1 specifies that the device server will return status as soon as the command descriptor block of the SET CAPACITY command has been validated. If Check Condition status is returned for a SET CAPACITY command with an Immed field set to 1, the set capacity operation has not been performed.

The Capacity Proportion Value field specifies the portion of the total unscaled tape capacity to be made available for use. This field is the numerator to a fraction that has a denominator of 65 535 (FFFFh). The resulting available capacity on the tape is equal to the total unscaled tape capacity multiplied by this fraction.

```
((Capacity Proportion Value) / 65 535) * (Total Unscaled Tape Capacity) =
(Resulting Available Capacity)
```

The tape drive may round up the capacity to the next highest supported value. This rounding is not considered an error and will not be reported. If the Capacity Proportion Valuedoes not meet the ranges specified in Table 148, or attempts to increase the available capacity to a value higher than it is currently set, then Check Condition status is returned with Illegal Field in CDB (5/2400h).

Table 148. Minimum Capacity Proportion Values

Drive Generation	Cartridge	Minimum Capacity Proportion Value	Resultant Approximate Minimum Capacity	Maximum Capacity
2	Ultrium 2	1605h	17.2 GB	200 GB
	Ultrium 3	N/A	N/A	N/A
2	Ultrium 2	1605h	17.2 GB	200 GB
	Ultrium 3	151 Ah	33 GB	400 GB
Note: Available and total tape capacities are approximate values that may be affected by defects which reduce the actual available capacity of the tape. Other factors, such as compression and block packing, may also affect available capacity.				

SPACE

The SPACE command instructs the drive to set a new logical position relative to the current logical position. How this is done depends on the value of the Code field and the Count field. The Count field is a signed value that indicates the distance to move. A negative value indicates movement towards BOM; a positive value indicates movement towards EOM.

Table 149. SPACE Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (11h)							
1	Logical Unit Number			Reserved		Code		
2 : 4	Count							
5	Control							

If the Code field is 000b, then the logical position is moved the number of blocks that is indicated by the Count field. If a filemark is encountered while spacing over blocks, the command is terminated. Check Condition status is returned, and the Filemark and Valid fields are set to 1 in the sense data. The Sense Key is set to No Sense and the Additional Sense Code is set to Filemark Detected. The Information field is set to the requested count minus the actual number of blocks spaced over (not including the filemark). The new logical position is set immediately after the file mark in the direction of the space operation. If BOM or EOD is detected before the requested logical position, then the logical position is set to that position.

If the Code field is 001b, then the logical position is moved the number of file marks indicated by the Count field. If BOM or EOD is detected before the requested logical position, then the logical position is set to that position.

If end-of-data is encountered while spacing over blocks or filemarks, Check Condition status is returned, the Sense Key is set to Blank Check, and the sense data Valid field is set to 1 in the sense data. The Additional Sense Code is set to End-Of-Data Detected. The sense data EOM field is set to 1 if end-of-data is encountered at or after early-warning. The Information field is set to the requested count minus the actual number of blocks or filemarks spaced over as defined by the Code value. The medium is positioned such that a subsequent write operation would append to the last record or filemark.

If the end-of-tape is encountered while spacing forward over blocks or filemarks, Check Condition status is returned, and the Sense Key is set to Medium Error. The Additional Sense Code is set to End-Of-Partition/Medium Detected, and the sense data EOM and Valid fields are set to 1. The Information field is set to the requested count minus the actual number of blocks or filemarks spaced over, as defined by the Code value.

If beginning-of-tape is encountered while spacing over blocks or filemarks in the reverse direction, the drive returns Check Condition status and sets the Sense Key to No Sense. The Additional Sense Code is set to Beginning-Of-Partition/Medium Detected. The sense data EOM and Valid fields are set to 1, and the Information

field is set to the total number of blocks or filemarks not spaced over (the requested number of blocks or filemarks minus the actual number of blocks or filemarks spaced over). A successfully completed SPACE command does not set EOM to 1 at beginning-of-tape.

If the Code field is 011b, then the logical position is set to after the last valid block on tape. In this case the Count field is ignored.

Any other value of the Code field causes Check Condition status to be returned. Spacing to sequential file marks is not supported. Set marks are not supported. The Sense Key is set to Illegal Request and the ASC/ASCQ is set to Invalid Field in CDB (2400).

TEST UNIT READY

The TEST UNIT READY command returns Good status if a cartridge is loaded and ready.

Table 150. TEST UNIT READY Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (00h)							
1	Logical Unit Number			Reserved				
2	Reserved							
3	Reserved							
4	Reserved							
5	Control							

VERIFY

The VERIFY command causes data to be read from the tape and passed through the drive's error detection and correction hardware to determine whether it can be recovered from the tape. The amount of data to be read is indicated by the Verification Length field and the Fixed field in the same manner as is used in a READ command. (See "READ" on page 74.)

Table 151. VERIFY Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (13h)							
1	Logical Unit Number			Reserved		Immed(0)	BCmp(0)	Fixed
2 : 4	Verification Length							
5	Control							

The VERIFY command is supported by all drives.

The Immed and BCmp fields are not supported and must be set to 0.

WRITE

The WRITE command causes data to be transferred to the drive in a Data Out and written to tape.

Table 152. WRITE Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (0Ah)							
1	Logical Unit Number			Reserved				Fixed
2 : 4	Transfer Length							
5	Control							

If the Fixed field is set to 1, the Block Length (see “Mode Block Descriptor” on page 53) is set to 0, and the Transfer Length field is not 0, Check Condition status is returned with Illegal Field in CDB (5/2400h).

If the Fixed field is set to 0, the initiator transfers a single block of the length indicated in Transfer Length.

If the Fixed field is set to 1, the initiator transfers a sequence of blocks. The number of blocks is given by the Transfer Length field. The length of the blocks is given by the current fixed block length (see “Mode Block Descriptor” on page 53).

If the current logical block number is greater than FFFFFF00h and less than FFFFFFF0h, rules for Logical EOM processing are applied. If the current logical block number is greater than or equal to FFFFFFF0h, rules for physical end of tape processing are applied.

WRITE ATTRIBUTE

Table 153. WRITE ATTRIBUTE Command

Byte	Bit							
	7	6	5	4	3	2	1	0
0	Operation Code (8Dh)							
1 : 4	Reserved							
5	Volume Number (0)							
6	Reserved							
7	Partition Number (0)							
8 : 9	Reserved							
10 : 13	Allocation Length							
14	Reserved							
15	Control							

Refer to *SCSI Primary Commands-3 (SPC-3)* for support for the WRITE ATTRIBUTE command.

For information about attributes that are supported, see "READ ATTRIBUTE" on page 76.

Table 154 gives the format of the data that is returned for an Attribute Values service action request.

Table 154. Parameter Data for Attribute Values Service Action Request

Byte	Bit							
	7	6	5	4	3	2	1	0
0 : 3	Parameter Data Length (n-3)							
4 : x	Attribute #1							
m : n	Attribute #y							

WRITE BUFFER

The WRITE BUFFER command transfers data into the memory on the drive for the purpose of diagnostics, tests, or firmware upgrade.

Table 155. WRITE BUFFER Command

Byte	Bit							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (3Bh)							
1	Logical Unit Number			Mode				
2	Buffer ID							
3 : 5	Buffer Offset							
6 : 8	Parameter List Length							
9	Control							

Values for the Mode field and their meaning are described in Table 156.

Table 156. Description of Mode Field

Mode	Description	Support
00h	Write combined header and data	1, 2, 3
02h	Write data	1, 2, 3
04h	Download microcode	1, 2, 3
05h	Download microcode and save	1, 2, 3
06h	Download microcode with offsets	1, 2, 3
07h	Download microcode with offsets and save	1, 2, 3
0Ah	Echo buffer	2, 3

Legend:

1 = supported in IBM TotalStorage LTO Ultrium Tape Drive (commonly called the Ultrium 1 tape drive)

2 = supported in IBM TotalStorage LTO Ultrium 2 Tape Drive (commonly called the Ultrium 2 tape drive)

3 = supported in IBM TotalStorage LTO Ultrium 3 Tape Drive (commonly called the Ultrium 3 tape drive)

If the Mode field is 00h, the data to be written is sent with a 4-byte header, which must be set to all zeroes.

The Buffer ID field indicates which buffer is to be written.

To download firmware, Modes 04h, 05h, 06h, and 07h are accepted and handled in the same fashion. Any Buffer ID value in these modes is allowed and ignored. The code must be downloaded with strictly increasing offsets. If it is not, no data is

written and Check Condition status is generated. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400). Ending status is given when the code has been successfully saved to flash, but before the drive has initiated its reset.

If Mode is set to 0Ah, the data is stored in the echo buffer. The Buffer ID and Buffer Offset fields are ignored in this mode.

The Buffer Offset field indicates where in the buffer the data should be written. This must be smaller than the size of the buffer.

The Parameter List Length field holds the amount of data. This must be smaller than the difference between the Buffer Offset field and the size of the buffer. If it is not, no data is written and Check Condition status is generated. The Sense Key is set to Illegal Request (5) and the ASC/ASCQ is set to Invalid Field in CDB (2400).

Buffers that may be written to are Test, Firmware, and VPD (see "READ BUFFER" on page 89).

WRITE FILE MARKS

The WRITE FILE MARKS command causes a sequence of file marks to be written at the current logical position. The number of file marks to be written is indicated in the Count field. If the Immed field is set, status is returned immediately, before the file marks are written to tape. If the Immed field is set to 0, the file marks and any buffered data is written to tape before status is returned.

The Write Set Mark (WSmk) field must be 0. Set marks are not supported.

Table 157. WRITE FILE MARKS Command

	Bit							
Byte	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	Operation Code (10h)							
1	Logical Unit Number			Reserved			WSmk(0)	Immed
2 : 4	Count							
5	Control							

If the Immed field is set to 0 and the Count field is 0, then all buffered data is flushed to tape before the status is reported.

If the current logical block number is greater than FFFFFF00h and less than FFFFFFF0h, rules for Logical EOM processing are applied. If the current logical block number is greater than or equal to FFFFFFF0h, rules for physical end of tape processing are applied.

A Write Filemark with Count set to 0 when there is no data in the buffer to be synchronized to media will always return Good Status. Good Status is returned even if the media is WORM media and the media is not at a writable location or the WORM media has been tampered with.

A Write Filemark with Count set to 0 when there is data in the buffer to be synchronized with media will return sense data as expected for a Write.

Chapter 4. Error Sense Information

Sense Data

For a description of Sense data, see "Sense Data Format" on page 105.

Sense Data Management

The drive maintains three types of Sense data:

Current Sense
The Sense data associated with the last command received from the initiator.

Deferred Sense
The Sense data from a command that has been reported as Good, but has generated sense data after being reported. This may be a command with the Immediate flag set or may be a buffered write. A command with the Immediate flag set generates sense for the server that sent the command. A buffered write may generate sense for all servers.

Unit Attention Sense
The Sense data generated by a Unit Attention condition. (See "Unit Attention Conditions" on page 141.) This is generated for all servers. When a Unit Attention condition has been driven by a command (for example, when mode parameters have changed), a Unit Attention is posted for all initiators except the one that caused the change.

Commands generate Check Condition status if there is Deferred Sense data or Unit Attention data available, depending on Table 6 on page 13. All commands generate Check Condition status if the command itself generates sense data. If the next command after the Check Condition status is not a REQUEST SENSE command, then all sense data for that initiator is cleared.

When a REQUEST SENSE command is received, the Current Sense is returned. If there is no Current Sense, the Deferred Sense is returned. If there is no Deferred Sense, the Unit Attention Sense is returned. If there is no Unit Attention Sense, default sense data is returned. Once a particular set of sense data has been returned, that sense data is cleared. Any other sense data that is still pending may still cause Check Condition status for subsequent commands.

Unit Attention Conditions

The drive generates a Unit Attention condition under the following circumstances:

- Reset condition (for example, power-on, SCSI reset, bus device reset)
- Tape Loaded condition (for example, media inserted, LOAD command from another initiator)
- Mode parameters changed by another initiator
- Drive firmware has been upgraded

The drive only maintains one Unit Attention condition at any one time for any one initiator. If a subsequent Unit Attention condition is generated, it replaces the

existing one if it is of higher priority. If it is of lower priority, it is ignored. The priorities are in the order listed above, with a reset being highest priority and a firmware upgrade being lowest priority.

Persistent Errors

When errors occur that prevent tape operation, they are reported persistently until the problem is cleared. For medium-related errors (usually reported with a Sense Key of 3), the error is reported until the cartridge is successfully unloaded. For hardware-related errors (usually reported with a Sense Key of 4), the error is reported until the drive successfully performs a power-on self test. These persistent errors are only reported on those commands that are eligible for deferred Check Condition reporting (see Table 4 on page 8). The error may or may not be reported as Deferred.

Fencing Behavior

The Ultrium 2 and Ultrium 3 drives will fence the drive (prevent certain operations) when errors are detected that could endanger customer data if further usage is allowed. The operations that are prevented depend on the nature of the error encountered and the current drive state. The drive will post an FSC for the original error that caused the fence condition. Then, fencing FSCs will be reported as status to the attempted host commands that are not allowed due to fence.

The following Fence states are defined and used:

1. ALLOW_NO_OPERATION
   a. All medium access commands (Read/Write/Motion) are rejected.
   b. (SCSI/Panel/LDI) Unload is accepted.
   c. After the cartridge is ejected:
      - When load is attempted, the cartridge stays at mount position and Good status is returned for TUR.
      - From the above state, the cartridge can be ejected normally.
      - Other medium access commands are rejected.
2. ALLOW_UNLOAD
   a. All medium access commands (Read/Write/Motion) are rejected.
   b. (SCSI/Panel/LDI) Unload is accepted.
   c. Once a cartridge is ejected, Fence state is cleared. You can load a new cartridge and perform all medium access commands.
3. ALLOW_ALLOCATE
   a. All medium access commands (Read/Write/Motion) are rejected.
   b. (SCSI/Panel/LDI) Unload is accepted.
   c. Once a cartridge is ejected, Fence state is cleared. You can load a new cartridge and perform all medium access commands.
   d. Space command is rejected while in Fence state.
4. MID-TAPE RECOVERY

   See the "Behavior Configuration Mode Page" on page 63 for a description of this behavior.

See Table 158 for the errors that trigger the fence states.

Table 158. Fence State to Error Mapping

Description	Fence State
ALLOW_NO_OPERATION	• Severe Drive Hardware problem • Severe Media Hardware problem • Temperature Overrange • Load or Unload Hardware problem • Severe Firmware Problem
ALLOW_LOCATE	• Hardware Problem detected that could affect Writing • Hardware Problem detected that could affect Reading
ALLOW_UNLOAD	• Serious Drive Hardware problem — May be recovered on a different mount • Serious Media problem — Drive may be recovered on different mount • Serious Firmware problem — May be recovered on different mount
MID-TAPE RECOVERY	See “Behavior Configuration Mode Page” on page 63

Chapter 5. WORM BEHAVIORS

Conditions for Writing

If the following condition is met, writing is allowed:

- the cartridge is uninitialized

If all the following conditions are met, writing is allowed:

- the current logical position is at BOT
- there are only filemarks between here and EOD

If all of the following conditions are met, writing is allowed:

- if the current logical position is at BOT
- there are exactly 1 or 2 data records, followed by 0 to infinite number of filemarks, followed by no data records, followed by EOD

If all of the following conditions are met, writing is allowed:

- the current logical position is BETWEEN BOT and EOD:
- there are only filemarks from the current logical position to EOD
- there is at least one filemark **immediately** before the current logical position

If the following condition is met, writing is allowed:

- the current logical position is AT EOD

Command Behavior When WORM Medium Has Been Tampered With

Table 159 specifies the behavior of the drive when it has detected the WORM medium that is loaded in the drive has been tampered with (See Sequential Access Drive Configuration page).

Table 159. Behavior when the loaded medium has suspect integrity

Command	WTRE=01b	WTRE=00b or 10b
Write	0x7/300D	0x7/300D
Write Filemark n (n !=0)	0x7/300D	0x7/300D
Write Filemark 0 (buffered data)	0x7/300D	0x7/300D
Write Filemark 0 (no buffered data)	Good	Good
Erase	0x7/300D	0x7/300D
Read	Good	0x3/300D
Verify	Good	0x3/300D
Space	Good	0x3/300D
Locate to (block !=0)	Good	0x3/300D
Locate to 0	Good	Good
Rewind	Good	Good
Unload	Good	Good

Table 159. Behavior when the loaded medium has suspect integrity (continued)

Command	WTRE=01b	WTRE=00b or 10b
Load	Good	Good

Chapter 6. Sense Keys and Additional Sense

This chapter lists all possible combinations of Sense Keys, Additional Sense Codes (ASC), and Additional Sense Code Qualifiers (ASCQ) that are reported by this device.

Sense Key 0 (No Sense)

Table 160. ASC and ASQ Summary for Sense Key 0 (No Sense)

ASC ASCQ	Description
00 00	No Additional Sense Information - (unsolicited, no CA/CC)
00 00	No Additional Sense Information - EOM=B'1' (Early Warning)
00 00	No Additional Sense Information - ILI=B'1'
00 00	No Additional Sense Information - FM=B'1'
00 01	Filemark Detected
00 02	End-of-Partition/Medium Detected (Early Warning)
00 04	Beginning-of-Partition/Medium Detected
00 16	Operation in Progress
82 82	Drive Requires Clearing

Sense Key 1 (Recovered Error)

Table 161. ASC and ASQ Summary for Sense Key 1 (Recovered Error)

ASC ASCQ	Description
00 00	No Additional Sense Information
0C 00	Write Error: A write error occurred, but was recovered. Data was successfully written to tape.
11 00	Read Error: A read error occurred, but was recovered. Data was successfully read from tape.
17 01	Recovered Data with Retries
17 01	Recovered Data with Retries
37 00	Mode Parameters Rounded
5D 00	Failure Prediction Threshold Exceeded
5D FF	Failure Prediction Threshold Exceeded (FALSE)

Sense Key 2 (Not Ready)

Table 162. ASC and ASQ Summary for Sense Key 2 (Not Ready)

ASC ASCQ	Description
04 00	Logical Unit Not Ready, Cause Not Reportable: A tape is present in the drive, but it is in the process of being unloaded.
04 01	Logical Unit Is in Process of Becoming Ready
04 02	Initializing Command Required: A tape is present in the drive, but it is not logically loaded.
04 12	Logical Unit Not Ready, Offline
30 03	Cleaning Cartridge Installed
30 07	Cleaning Failure
3A 00	Medium Not Present
3E 00	Logical Unit Has Not Self-configured

Sense Key 3 (Medium Error)

Table 163. ASC and ASQ Summary for Sense Key 3 (Medium Error)

ASC ASCQ	Description
04 10	Logical Unit Not Ready, Auxiliary Memory Not Accessible
09 00	Track Following Error (Servo)
0C 00	Write Error
11 00	Unrecovered Read Error
11 12	Auxiliary Memory Read Error
14 00	Recorded Entity Not Found
30 00	Incompatible Medium Installed
30 01	Cannot Read Medium, Unknown Format
30 02	Cannot Read Medium, Incompatible Format
30 0D	Medium Error/WORM Medium - Integrity Check: Set when the drive rejects a Read operation because the current cartridge is a Suspicious WORM cartridge, and the WTRE bit is set to 0.
31 00	Medium Format Corrupted
3B 00	Sequential Positioning Error
50 00	Write Append Error
51 00	Erase Failure
52 00	Cartridge Fault
53 00	Media Load or Eject Failed

Sense Key 4 (Hardware or Firmware Error)

Table 164. ASC and ASQ Summary for Sense Key 4 (Hardware or Firmware Error)

ASC ASCQ	Description
04 03	Manual Intervention Required: A tape is present in the drive but could not be loaded or unloaded without manual intervention.
08 01	Logical Unit Communication Failure
40 XX	Diagnostic Failure: The Additional Sense Code Qualifier indicates the failing component.
41 00	Data Path Failure
44 00	Internal Target Failure
51 00	Erase Failure
53 00	Media Load or Eject Failed

Sense Key 5 (Illegal Request)

Table 165. ASC and ASQ Summary for Sense Key 5 (Illegal Request)

ASC ASCQ	Description
1A 00	Parameter List Length Error
20 00	Invalid Command Operation Code
24 00	Invalid Field in CDB
25 00	Logical Unit Not Supported
26 00	Invalid Field in Parameter List
29 04	Device Internal Reset
2C 00	Command Sequence Errro
3B 0C	Position Past Beginning of Medium: A command that required the medium to be at BOP was attempted when the medium was not at BOP (e.g., Set Capacity).
53 02	Medium Removal Prevented
82 83	Bad Microcode Detected: The data transferred to the drive during a firmware upgrade is corrupted or incompatible with the drive hardware.
A3 01	OEM Vendor-Specific

Sense Key 6 (Unit Attention)

Table 166. ASC and ASQ Summary for Sense Key 6 (Unit Attention)

ASC ASCQ	Description
28 00	Not Ready to Ready Transition, Medium May Have Changed
28 01	Import or Export Element Accessed
29 00	Power On, Reset, or Bus Device Reset Occurred: This also occurs on Fibre Channel drives when a host logs in (PLOGI).

Table 166. ASC and ASQ Summary for Sense Key 6 (Unit Attention) (continued)

ASC ASCQ	Description
2A 01	Mode Parameters Changed
2F 00	Commands Cleared by Another Initiator
3F 03	Inquiry Data Has Changed
3F 0E	Reported LUNs Data Has Changed
5D FF	Failure Prediction False: A MODE SELECT command has been used to test the Failure Prediction System.
5A 01	Operator Medium Removal Request

Sense Key 7 (Data Protect)

Table 167. ASC and ASQ Summary for Sense Key 7 (Data Protect)

ASC ASCQ	Description
27 00	Write Protected
30 05	Cannot Write Medium, Incompatible Format
30 0D	Data Protect/WORM Medium - Integrity Check: Set when the drive rejects a Write operation because the current cartridge is a Suspicious WORM cartridge.
30 0C	Data Protect/WORM Medium - Overwrite Attempted: Set when the drive rejects a Write operation because the rules for allowing WORM writes have not been met.
52 00	Cartridge Fault

Sense Key 8 (Blank Check)

Table 168. ASC and ASQ Summary for Sense Key 8 (Blank Check)

ASC ASCQ	Description
00 05	End-of-Data (EOD) Detected
14 03	End-of-Data (EOD) not Found

Sense Key B (Aborted Command)

Table 169. ASC and ASQ Summary for Sense Key B (Aborted Command)

ASC ASCQ	Description
3D 00	Invalid Bits in Identify Message
3F 0F	Echo Buffer Overwritten
43 00	Message Error
45 00	Select/Reselect Failure

Table 169. ASC and ASQ Summary for Sense Key B (Aborted Command) (continued)

ASC ASCQ	Description
48 00	Initiator Detected Error Message Received
49 00	Invalid Message Error
4A 00	Command Phase Error
4B 00	Data Phase Error
4E 00	Overlapped Commands
00 02	End-of-Partition/Medium Detected

Sense Key D (Volume Overflow)

Table 170. ASC and ASQ Summary for Sense Key D (Volume Overflow)

ASC ASCQ	Description
00 02	End-of-Partition/Medium Detected

Chapter 7. Attachment Features

Types of Interface Attachments

The Ultrium Tape Drive communicates with servers that use SCSI parallel or Fibre Channel interfaces. The interfaces share certain tape LUN behaviors, but also possess unique features. This chapter describes the common and unique features of both types of interfaces.

Common Tape LUN Behaviors

SCSI parallel and Fibre Channel interfaces share the following tape LUN behaviors:

- Power-on procedure
- Reset strategy
- Abort handling
- Multi-initiator support
- Status codes

The sections that follow describe each behavior.

Power-On

The drive responds to INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY commands within 5 seconds of power-on. The first command (other than INQUIRY or REQUEST SENSE) from any initiator gets a Check Condition status with Unit Attention sense data for the power-on. After this, any medium access command is reported with a Sense Key of Not Ready and an ASC/ASCQ of LUN Has Not Self-Configured Yet (3E00). Once the drive has completed its self test and setup procedures, the drive attempts to load any tape that is present. Medium access commands are reported with an ASC/ASCQ of Drive in Process of Becoming Ready (0401).

Reset Strategy

The drive supports the hard reset option as is required by SCSI-3. On receiving a reset, the following actions are taken:

- The current I/O process is aborted, as in "Abort Handling" on page 154.
- Any queued I/O processes from other initiators are removed.
- All reservations are cleared.
- All mode values are reset to their defaults.
- Synchronous/Wide negotiations are cleared (applies only to SCSI parallel attach).
- A unit attention condition is set.
- A logical position is established that may or may not be the same as the position prior to the reset. Where possible, the logical position prior to reset is maintained.

For drives that use a Fibre Channel interface, the next command that is eligible for the Unit Attention Check Condition from each initiator gets a Check Condition status, with Unit Attention sense data for the reset. However, other commands may not be processed until the internal state of the drive has been reset.

Drives that use a SCSI interface are able to respond to the INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY commands within 250 ms of the reset line being released. The next command that is eligible for the Unit Attention Check Condition from each initiator gets a Check Condition status, with Unit Attention sense data for the reset. However, other commands may not be processed until the internal state of the drive has been reset. Any commands that allow Disconnects and cannot be processed are accepted and queued until the drive is ready to process them. Those commands that do not allow Disconnects receive Busy status response.

Abort Handling

If a command is aborted on a drive with a Fibre Channel interface, see Table 171 for abort processing.

If a command is aborted on a drive with a SCSI interface, one of the following conditions will occur:

- If an abort condition is detected before a command phase completes, the bus is set to Bus Free and the command is not executed.
- If an abort condition is detected during status phase, the bus is set to bus free.
- If an abort condition is detected between the end of the command phase and the start of the status phase, then the bus is set to Bus Free and the processing in Table 171 on page 154 is carried out.

Table 171. Abort Condition Handling

Command	Abort Processing
ERASE	Long erase is aborted as quickly as possible without corrupting tape format. Short erase completes.
INQUIRY	None.
LOAD/UNLOAD	Load completes and logically positions tape at BOM. Unload is aborted, leaving logical position at BOM unless operation is past the 'point of no return', in which case the tape is ejected.
LOCATE	The logical position is set back to that at the start of the operation unless the operation is past its 'point of no return', in which case the operation completes.
LOG SELECT	If data transfer is completed, command is completed; otherwise, no action is taken.
LOG SENSE	None.
MODE SELECT	If data transfer is completed, command is completed; otherwise, no action is taken.
MODE SENSE	None.
PERSISTENT RESERVE IN	None.
PERSISTENT RESERVE OUT	If data transfer is completed, the command is completed; otherwise, no action is taken.
PREVENT/ALLOW MEDIUM REMOVAL	The command completes.
READ	The current position is set to the first record boundary at or after the start of the current data burst.
READ ATTRIBUTE	None.
READ BLOCK LIMITS	None.

Table 171. Abort Condition Handling (continued)

Command	Abort Processing
READ BUFFER	None.
READ POSITION	None.
RECEIVE DIAGNOSTIC RESULTS	None.
RELEASE UNIT	The command completes.
REPORT DENSITY SUPPORT	None.
REPORT LUNs	None.
REQUEST SENSE	Sense data is discarded.
RESERVE UNIT	The command completes.
REWIND	The command completes.
SEND DIAGNOSTIC	Vendor unique.
SPACE	The logical position is set back to that at the start of the operation unless the operation is past its 'point of no return', in which case the operation completes.
TEST UNIT READY	None.
VERIFY	The logical position is set to the next record boundary after the point where the verify was aborted.
WRITE	The data up to first record boundary in the current burst is written to buffer or tape, depending on Buffered Mode. Any subsequent data is discarded. If there is no record boundary in the current burst, the record is truncated to the amount of data transferred and written to buffer or tape, again depending on Buffered Mode.
WRITE BUFFER	If data transfer is completed, the command is completed; otherwise, no action is taken.
WRITE FILE MARKS	The command completes.

For drives with a SCSI interface, if a command other than INQUIRY, REPORT LUNs, REQUEST SENSE, or TEST UNIT READY is received after the abort but before the drive is ready to process the command, the drive attempts to disconnect and wait until the abort processing has completed before executing the command. If disconnects are not allowed, Busy status is returned. A TEST UNIT READY command reports with status immediately.

For drives with a Fibre Channel interface, an INQUIRY command returns the required data and gives Good status. A REQUEST SENSE command gives no sense. A TEST UNIT READY command reports with status immediately.

Multi-initiator Support

SCSI-attached drives support a maximum of two initiators on the same bus. Fibre-Channel-attached drives support an infinite number of initiators, but have a limit on how many initiators can be logged in concurrently. When this limit is exceeded, the least recently used (LRU) initiator that is not reserved or does not have an outstanding command will be implicitly logged out.

The drive supports untagged queuing when operating with multiple initiators. If a command from one initiator is being processed when a command other than INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY is received from a second initiator, the new command is queued. Media access commands (e.g., Write, Write Filemarks, Read, Verify, Rewind, Mode Select that changes block size) are always executed in strict order of receipt. For drives with a SCSI interface, if the queue is full or disconnect privilege is not granted in the new command, the drive reports busy status.

The INQUIRY, REPORT LUNs, REQUEST SENSE, and TEST UNIT READY commands are always processed immediately, irrespective of whether a command from another initiator is being processed.

The drive maintains sense data for the supported number of initiators. On Fibre-Channel-attached drives, if an additional initiator connects to the drive and causes an initiator to be implicitly logged out, the drive erases all sense data for that initiator before processing the command for the new initiator. See "Sense Data Management" on page 141 for more details of sense data management.

Status Codes

Table 172. Status Codes

Status Code	Value	Circumstance
Good	00h	The command completed without problems.
Check Condition	02h	A problem occurred during command execution. The sense data should be examined to determine the nature of the problem.
Busy	08h	The drive is unable to accept the command at this time. This status is returned during the power-on sequence or if there are commands from too many initiators outstanding. (See "Multi-initiator Support" on page 156.) It is also returned when commands are issued without Disconnect Privilege and when another command is in progress.
Reservation Conflict	18h	This status is returned if the drive is reserved for an initiator other than the one sending the command.
Queue Full	28h	Not normally returned.

Features of the SCSI Interface

The Ultrium Tape Drive's SCSI parallel interface features the following:

- LUN identification
- Bus parity errors
- Disconnect strategy
- Messages

LUN Identification

Identify messages are used to identify the LUN to which an initiator is connecting and to identify which LUN is reconnecting to an initiator. These are required. The LUN field in SCSI-2 commands is not used.

Bus Parity Errors

On detecting a bus parity error during a Command or Data Out phase or receiving an Initiator Detected Error message during a Data In or Status phase, the drive attempts to retry the Bus phase. A Restore Pointers message is sent to the initiator and the transfer is repeated. Only one retry is attempted for any given burst. If the retry fails or the Restore Pointers message is rejected by an Initiator Detected Error, Message Reject, or Message Parity message, then the drive goes to the Status phase and attempts to report Check Condition status. If this fails with an Initiator Detected Error message, the drive goes to Bus Free. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to Command Phase Error (4A00) (if the error was in the Command phase) or to Data Phase Error (4B00) (if the error was in the Data phase). If the error was in the Status phase, the sense data remains as that from the command.

If an Initiator Detected Error or Message Parity Error message is received during the Message In phase, the initiator has detected an error in the message. The drive goes to Message In and resends the message that was in error. If the subsequent message is rejected with an Initiator Detected Error, then the drive goes to the Status phase and sends Check Condition status. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to Initiator Detected Error (4800). If the subsequent message is rejected with a Message Parity Error, then the drive goes to the Status phase and sends Check Condition status. The Sense Key is set to Aborted Command and the ASC/ASCQ is set to Message Error (4300).

On detecting a bus parity error during a Message Out phase, the drive handshakes in all message bytes until ATN is deasserted. It then stays in the Message Out phase to indicate to the initiator that the whole Message Out phase should be resent.

Disconnect Strategy

The disconnect strategy used by the drive is based on the assumption of maximizing bus utilization for large sequential data transfers from a large data buffer. The drive disconnects whenever it believes that it can provide better bus utilization. This may be between Command and Data phases, between bursts of data, or before sending status. However, the drive guarantees that it sends the configured maximum burst size or the remaining data in the transfer in any single Data phase burst if the maximum burst size has been set to a value other than 0.

Messages

Message Out

Table 173. Supported Outbound Messages

Name	Code	Support
Abort	06h	An abort condition is generated (see "Abort Handling" on page 154).
Bus Device Reset	0Ch	A reset condition is generated (see "Abort Handling" on page 154).
Extended Message	01h	See "Unit Attention Conditions" on page 141 for extended message support.
Identify	80h+	The Identify Out message is sent by the initiator to identify the Logical Unit to be accessed and to set Disconnect Privilege. The LUNTAR flag must be 0. The Identify Out message must be sent as the first thing after selection. If it is sent at any other time, the drive responds with a Message Reject message and goes to Bus Free.
Initiator Detected Error	05h	The initiator has detected an error in the data being sent in a Message Command, Data, or Status phase. The drive retries the data burst or message (see "Bus Parity Errors" on page 157). If the message is received immediately after an Identify message or after the Command Complete message has been sent, the drive goes to Bus Free.
Message Parity Error	09h	The initiator has detected a parity error in a message. The drive retries the message (see "Bus Parity Errors" on page 157). If the message is received during a Command, Data, or Status phase, immediately after an Identify message, or after the Command Complete message has been sent, the drive goes to Bus Free.
Message Reject	07h	This message is sent when the initiator does not support a message sent by the drive or considers the message inappropriate. If the message being rejected is Disconnect, Synchronous Data Transfer Request, or Wide Data Transfer Request, the operation continues without those features. For all other messages except Restore Pointers, the message is treated as an Abort message. If the message is received during a Command, Data, or Status phase, immediately after an Identify message, or after the Command Complete message has been sent, the drive goes to Bus Free.
No Operation	08h	This message has no effect and is ignored.

Message In

Table 174. Supported Inbound Messages

Name	Code	Support
Command Complete	00h	This message is sent by the drive at the end of the Status phase to indicate that a command is complete. Once the message is sent, the drive releases the bus and goes to Bus Free.
Disconnect	04h	This message is sent by the drive to indicate that it is about to disconnect from the bus and go to Bus Free. During a Data phase, it is always preceded by a Save Data Pointers message. If a Message Reject message is received in response to this message, then the disconnect is prevented.
Extended Message	01h	See “Extended Messages” on page 160 for extended message support.
Identify	80h+	The Identify In message is sent to the initiator during reconnect to indicate which Logical Unit is reconnecting. The Disconnect Privilege and LUNTAR flags are both clear.
Ignore Wide Residue	23	This message is sent by the drive to the initiator to indicate that a byte on a wide bus is not valid. This is supported whenever a wide transfer is active.
Message Reject	07h	This message is sent to the initiator when the message received by the drive is unsupported or inappropriate.
Restore Pointers	03h	This message causes the initiator to reset its data transfer pointers to the values they held when the last Save Data Pointers message was sent. It is sent when a parity error is detected on the bus or when an Initiator Detected Error message is received in order to retry the Data phase.
Save Data Pointers	02h	This message instructs the initiator to save its current data transfer pointers for use with a subsequent Restore pointers message. This message is always sent before a Disconnect message during Data phases.

Extended Messages

Table 175. Supported Extended Messages

Name	Code	Support
Synchronous Data Transfer Request	01h	The default mode is for the drive to never initiate a Synchronous data transfer negotiation. The initiator is expected to do so. Since this mode is most important at power-on, no SCSI method of changing this mode is provided. Instead, an internal method of changing this mode is provided (VPD or jumper setting). If the message is received after selection and before the Command phase, it then goes to the Message In phase and responds with a valid response to complete the negotiation. If the message is received at any other time, a Message Reject is sent in response, placing the drive data transfer mode for that initiator to asynchronous.
Wide Data Transfer Request	03h	The default mode is for the drive to never initiate a Wide data transfer negotiation. The initiator is expected to do so. Since this mode is most important at power-on, no SCSI method of changing this mode is provided. Instead, an internal method of changing this mode is provided (VPD or jumper setting). If the message is received after selection and before the Command phase, it then goes to the Message In phase and responds with a valid response to complete the negotiation. If the message is received at any other time, a Message Reject is sent in response, placing the Bus Width to 1 byte wide and data transfer mode to asynchronous for that initiator.

Features of the Fibre Channel Interface

The Ultrium Internal Tape Drive Model T200F (the Fibre Channel Generation 1 drive) is an Arbitrated-Loop-only device (also known as an NL port). The drive supports Fibre Channel Arbitrated Loop (FC-AL) protocol, and uses Class 3 Service frames. The drive also supports both public (switch-attached) and private loops.

Like the Ultrium Internal Tape Drive, the Ultrium 2 Tape Drive Model T400F (the Fibre Channel Generation 2 drive) and the IBM TotalStorage Ultrium 3 Tape Drive Model T800F (the Fibre Channel Generation 3 drive) can attach as an FC-AL device (that is, L-Port). The drives also support operating as a public (switch-attached) or private device (that is, L-Port to FL-Port; or L-Port to L-Port). The Ultrium 2 and Ultrium 3 drives can also attach using the point-to-point protocol (also known as an N-Port). When operating in the point-to-point protocol, the Ultrium 2 and Ultrium 3 drives can attach in a Fabric topology (that is, N-Port to F-Port).

The World Wide Node Name and Port Name that are used by an Ultrium Tape Drive follow the format of the Institute of Electrical and Electronics Engineers (IEEE).

The IBM Ultrium Tape Drive is compliant with the FC-Tape Technical Report of the Accredited Standard Committee NCITS. IBM recommends that your server's device driver and host bus adapter (HBA) use the Class 3 Error Recovery procedures that are specified in the Fibre Channel Protocol for SCSI, Second Version (FCP-2).

Appendix. Notices

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Glossary

This glossary defines the special terms, abbreviations, and acronyms that are used in this publication.

Numbers and Symbols

2:1 compression. The relationship between the quantity of data that can be stored with compression as compared to the quantity of data that can be stored without compression. In 2:1 compression, twice as much data can be stored with compression as can be stored without compression.

A

adapter. See *adapter card*.

adapter card. A circuit board that adds function to a computer.

AL_PA. See *Arbitrated Loop Physical Address*.

Arbitrated Loop Physical Address (AL_PA). An 8-bit value that identifies a device in an arbitrated loop. All Fibre Channel ports communicate by using AL_PAs.

B

backups. The short-term retention of records used for restoring essential business and server files when vital data has been lost because of program or server errors or malfunctions.

bezel. The removable frame that fits over the front of the Ultrium Tape Drives.

bit. The smallest unit of data in a computer. A bit (short for binary digit) has a single binary value (either 0 or 1). Computers store data and execute instructions in bit multiples called bytes. In most computer systems, there are eight bits in a byte.

bus. See *SCSI bus*.

byte. A string that consists of a certain number of bits (usually 8) which are treated as a unit and represent a character. A byte is a fundamental unit of data.

C

capacity. The amount of data that can be contained on storage media and expressed in bytes.

cartridge. See *tape cartridge*.

cartridge memory. See *LTO cartridge memory*.

circuit board. A thin sheet on which chips and other electronic components are placed. Computers consist of one or more boards, often called cards or adapters.

cleaning cartridge. A tape cartridge that is used to clean the heads of a tape drive. Contrast with *data cartridge*.

command timeout. Following the issuance of a command, a period of time during which it is determined that there is a bad connection between the server and the drive.

compression. The process of eliminating gaps, empty fields, redundancies, and unnecessary data to shorten the length of records or blocks.

configure. To describe to a server the devices, optional features, and programs installed on the system.

D

data. Any representations such as characters or analog quantities to which meaning is, or might be, assigned.

data cartridge. A tape cartridge that is dedicated to storing data. Contrast with *cleaning cartridge*.

data compression. See *compression*.

data transfer rate. The average number of bits, characters, or blocks per unit of time that pass between corresponding equipment in a data transmission system. The rate is expressed in bits, characters, or blocks per second, minute, or hour.

device. Any hardware component or peripheral, such as a tape drive or tape library, that can receive and send data.

device driver. A binary file that is installed on a host system and enables the host system to access a device.

diagnostic. A software program that is designed to recognize, locate, and explain faults in equipment or errors in programs.

diagnostic cartridge. A tape cartridge that enables the detection and isolation of errors in programs and faults in equipment.

drive. See *IBM Ultrium Internal Tape Drive Models T200 and T200F* or *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

drive dump. The recording, at a particular instant, of the contents of all or part of one storage device into another storage device, usually as a safeguard against faults or errors, or in connection with debugging.

drive head. The component that records an electrical signal onto magnetic tape, or reads a signal from tape into an electrical signal.

drive sense data. See *SCSI drive sense data*.

dump. See *drive dump*.

duplex. See *duplex transmission*.

duplex adapter. A mechanism that allows a device to send and receive communication at the same time.

duplex transmission. Transmission in both directions, either one direction at a time (half-duplex) or both directions simultaneously (full-duplex).

E

eject. To remove or force out from within.

electronic mail. Correspondence in the form of messages transmitted between user terminals over a computer network.

e-mail. See *electronic mail*.

enclosure. A device, such as a desktop unit, tape cartridge autoloader, or tape library, into which you can install an Ultrium Tape Drive.

error log. Maintained by an Ultrium Tape Drive, a list that contains the ten most recent error codes. The codes identify errors that pertain to the drive.

F

Fibre Channel. A 100-MB-per-second, full-duplex, serial communications technology that is capable of interconnecting Ultrium Tape Drives and servers which are separated by as much as 11 kilometers (7 miles). Fibre Channel technology combines features of the input/output (I/O) and networking interfaces.

Fibre Channel cable. The cable that connects a Fibre Channel tape drive to another device. The conductive element within the cable is constructed of either copper wires or optical fibers. Generally, copper wires are used for short distances (up to 30 meters or 98 feet); optical fibers are used for longer distances. Fiber-optic cabling is referred to by mode or the frequencies of light waves that are carried by a particular cable type. Multimode fiber cables are generally used for distances up to 500 meters (1640 feet) and with short-wave (780 nanometer) laser light. Single-mode fiber cables are used for distances greater than 500 m (1640 feet) and with long-wave (1300 nanometer) laser light.

file. A named set of records that are stored or processed as a unit.

filemark. Located on the magnetic tape within a tape cartridge, a recorded element that typically marks the organizational boundaries in a serial file structure (such as directory boundaries) and that is requested to be written or read by the server.

firmware. Proprietary code that is usually delivered as part of an operating system. Firmware is more efficient than software that is loaded from an alterable medium, and is more adaptable to change than pure hardware circuitry. An example of firmware is the Basic Input/Output System (BIOS) in read-only memory (ROM) on a PC motherboard.

G

Gb. See *gigabit*.

GB. See *gigabyte*.

gigabit (Gb). 1 000 000 000 bits.

gigabyte (GB). 1 000 000 000 bytes.

H

hard addressing. Pertaining to the Fibre Channel drives (Models T200F and T400F), a method that identifies the drive's LID and, consequently, its AL_PA (the AL_PA enables the drive to communicate with other devices).

hardware. The physical equipment or devices that form a computer.

head. See *drive head*.

host. The controlling or highest-level system in a data communication configuration. Synonymous with *server*.

I

IBM Ultrium Internal Tape Drive Models T200 and T200F. A data-storage device that controls the movement of the magnetic tape in an IBM LTO Ultrium Tape Cartridge. The drive houses the mechanism (drive head) that reads and writes data to the tape. Its native data capacity is 100 GB per cartridge and up to 200 GB at 2:1 compression. Its native data transfer rate is 15 MB per second and 30 MB per second at 2:1 compression.

IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F. A data-storage device that controls the movement of the magnetic tape in an IBM LTO Ultrium Tape Cartridge. The drive houses the mechanism (drive head) that reads and writes data to the tape. Its native data capacity is 200 GB per

cartridge and up to 400 GB at 2:1 compression. Its native data transfer rate is 35 MB per second and 70 MB per second at 2:1 compression.

ID. Identifier.

initiator. In SCSI terms, a SCSI device that requests an I/O process to be performed by another SCSI device (a target). In many cases, an initiator can also be a target.

input/output (I/O). Data that is provided to a computer or data that results from computer processing.

install. (1) To set up for use or service. (2) The act of adding a product, feature, or function to a server or device either by a singular change or by the addition of multiple components or devices.

Internet. The worldwide collection of interconnected networks that use the Internet suite of protocols and permit public access.

I/O. See *input/output*.

J

jumper. (1) A tiny connector that fits over a pair of protruding pins in a connector. A jumper can be moved to change electrical connectors. When in place, the jumper connects the pins electrically. (2) To place a jumper on a connector pin.

L

Linear Tape-Open (LTO). A type of tape storage technology developed by the IBM Corporation, Hewlett-Packard, and Seagate. LTO technology is an "open format" technology, which means that its users have multiple sources of product and media. The "open" nature of LTO technology enables compatibility between different vendors' offerings by ensuring that vendors comply with verification standards.

load. Following the insertion of a tape cartridge into the tape load compartment, the act of positioning the tape (performed by the tape drive) for reading or writing by the drive's head.

load and unload cycle. The act of inserting a cartridge into a tape drive, loading the tape to load point, rewinding the tape into the cartridge, and ejecting the cartridge from the drive.

log sense data. See *SCSI log sense data*.

Low Voltage Differential (LVD). A low-noise, low-power, and low-amplitude electrical signaling system that enables data communication between a supported server and the Ultrium Tape Drive. LVD signaling uses two wires to drive one signal over copper wire. The use of wire pairs reduces electrical noise and crosstalk.

LTO. See *Linear Tape-Open*.

LTO cartridge memory (LTO-CM). Within each LTO Ultrium Data Cartridge, an embedded electronics and interface module that can store and retrieve a cartridge's historical usage and other information.

LTO-CM. See *LTO cartridge memory*.

LTO-DC. See *LTO Data Compression*.

LTO Data Compression (LTO-DC). A method that compresses a server's data before the drive writes it to tape. LTO-DC detects but does not recompress or test record boundaries and file markers (which are encoded as control symbols). It also allows switching between compression and no compression within the data stream, which prevents data from expanding when the drive compresses random or encrypted data.

LVD. See *Low Voltage Differential*.

M

magnetic tape. A tape with a magnetizable surface layer on which data can be stored by magnetic recording.

MB. See *megabyte*.

media. The plural of *medium*.

media capacity. See *capacity*.

medium. A physical material in or on which data may be represented, such as magnetic tape.

megabyte (MB). 1 000 000 bytes.

micrometer. One millionth of a meter (.000001 m). Synonymous with *micron*. Abbreviated as µm.

micron. One millionth of a meter (.000001 m). Synonymous with *micrometer*. Abbreviated as µm.

microsecond. One millionth of a second (.000001 s). Abbreviated as µs.

millimeter (mm). One thousandth of a meter (.001 m).

millisecond (ms). One thousandth of a second (.001 s).

mm. See *millimeter*.

ms. See *millisecond*.

Model T200. The version of the IBM Ultrium Internal Tape Drive that uses the SCSI interface, has a native storage capacity of 100 GB, and a native data transfer rate of 15 MB per second.

Model T200F. The version of the IBM Ultrium Internal Tape Drive that uses the Fibre Channel interface, has a native storage capacity of 100 GB, and a native data transfer rate of 15 MB per second.

Model T400. The version of the IBM TotalStorage LTO Ultrium 2 Tape Drive that uses the SCSI interface, has a native storage capacity of 200 GB, and a native data transfer rate of 35 MB per second.

Model T400F. The version of the IBM TotalStorage LTO Ultrium 2 Tape Drive that uses the Fibre Channel interface, has a native storage capacity of 200 GB, and a native data transfer rate of 35 MB per second.

N

N/A. Not applicable.

native storage capacity. The amount of data that can be stored without compression on a tape cartridge.

native sustained data transfer rate. See *data transfer rate*.

network. A configuration of data processing devices and software that is connected for information interchange.

network server. In a local area network, a personal computer that provides access to files for all of the workstations in the network.

node. In Fibre Channel technology, a communicating device.

ntutil. Created by IBM, a utility program for LTO devices that connect to Windows NT and Windows 2000. *ntutil* provides problem determination for hardware or connections, assists with device and medium changer recognition, forces dumps, loads new firmware, sends and receives SCSI commands to and from the hardware, and obtains SCSI sense data to use in resolving errors.

O

offline. The operating condition that the Ultrium Tape Drives are in when the server's applications cannot interact with it.

online. The operating condition that the Ultrium Tape Drives are in when the server's applications can interact with it.

Open Systems. Computer systems whose standards are not proprietary.

operating system. The master computer control program that translates the user's commands and allows software application programs to interact with the computer's hardware.

P

parity. The state of being even-numbered or odd-numbered. A parity bit is a binary number that is added to a group of binary numbers to make the sum of that group always odd (odd parity) or even (even parity).

parity error. A transmission error that occurs when the received data does not have the parity that is expected by the receiving system. This usually occurs when the sending and receiving systems have different parity settings.

port. (1) A system or network access point for data entry or exit. (2) A connector on a device to which cables for other devices such as display stations and printers are attached. (3) The representation of a physical connection to hardware. A port is sometimes referred to as an adapter; however, there can be more than one port on an adapter.

power-off. To remove electrical power from a device.

power-on, powered-on. (1) To apply electrical power to a device. (2) The state of a device when power has been applied to it.

protocol. The meanings of, and the sequencing rules for, requests and responses that are used to manage a network, transfer data, and synchronize the states of network components.

Q

quiesce. To put a device into a temporarily inactive or inhibited state, but not remove it from the server.

R

read. To acquire or interpret data from a storage device, from a data medium, or from another source.

reboot. To reinitialize the execution of a program by repeating the initial program load (IPL) operation.

record. The smallest distinct set of data bytes that is supplied from a server for processing and recording by a tape drive, and the smallest distinct set of data to be read from tape, reprocessed, and made available to a server by a tape drive.

record boundaries. The fixed limits of a record.

repeater. A device that regenerates signals to extend the range of transmission between data stations or to interconnect two branches. A repeater is a node of a local area network.

reset. To return a device or circuit to a clear state.

RS-422 connector. Located at the rear of the Ultrium Tape Drive, the connector to which the internal RS-422 cable of an enclosure connects. The connection enables serial devices to communicate with the drive.

RS-422 interface. An electrical interface standard that is approved by the Electronic Industries Association (EIA) for connecting serial devices. The RS-422 standard, which supports higher data rates and greater immunity to electrical interference, is an alternative to the older RS-232 interface, and uses individual differential signal pairs for data transmission. Depending on data transmission rates, RS-422 can be used at distances up to 1,275 m (4,000 ft). The RS-422 interface also supports multi-point connections.

S

s. See *second*.

SAN. See *Storage Area Network*.

SAN Data Gateway. A device that provides Fibre Channel attachment between Open Systems servers and SCSI disk and tape storage systems.

SC. See *subscription channel connector*.

SCSI. See *Small Computer Systems Interface*.

SCSI bus. (1) A collection of wires through which data is transmitted from one part of a computer to another. (2) A generic term that refers to the complete set of signals that define the activity of the Small Computer Systems Interface (SCSI).

SCSI connector. Located at the rear of the Ultrium Tape Drive, the connector that facilitates commands to and from the server, and to which the internal SCSI cable of an enclosure connects.

SCSI device. Anything that can connect into the SCSI bus and actively participate in bus activity.

SCSI drive sense data. In response to inquiry from the server about an error condition, a packet of SCSI sense bytes that contains information about the error and that is sent back to the server by the drive.

SCSI ID. The unique address (from 1 to 15) that you assign to an Ultrium Tape Drive that uses a SCSI interface.

SCSI ID connector. Located at the rear of the Ultrium Tape Drive, the connector that enables the drive's SCSI address to be set. Addresses are determined by the placement of jumpers on the pins.

SCSI ID switch. Located on an enclosure that contains a Ultrium Tape Drive, a mechanism that connects to the drive and allows you to change the drive's SCSI ID without using jumpers.

SCSI log sense data. In response to inquiry from the server about the Ultrium Tape Drive's error logs and counters, a packet of SCSI sense bytes which contains that information and which is sent back to the server by the drive. Log sense data is used to diagnose problems, especially if the problems are intermittent.

second. One sixtieth of a minute.

selection timeout. Following the selection of an option (for example, a data transfer), the period of time during which it is determined that there is a bad connection between the server and the drive.

sense data. Data that describes an I/O error. Sense data is presented to a server in response to a Sense I/O command.

serial interface. An interface that sequentially or consecutively executes two or more operations in a single device, such as an arithmetic and logic operation.

server. A functional unit that provides services to one or more clients over a network. Examples include a file server, a print server, or a mail server. The IBM @server pSeries, IBM @server iSeries, HP, and Sun are servers. Synonymous with *host*.

short-wave cable. In Fibre Channel technology, a laser cable that uses a wavelength of 780 nanometers and is only compatible with multimode fiber.

Small Computer Systems Interface (SCSI). A standard used by computer manufacturers for attaching peripheral devices (such as tape drives, hard disks, CD-ROM players, printers, and scanners) to computers (servers). Pronounced "scuzzy." Variations of the SCSI interface provide for faster data transmission rates than standard serial and parallel ports (up to 160 megabytes per second). The variations include:

- Fast/Wide SCSI: Uses a 16-bit bus, and supports data rates of up to 20 MBps.
- SCSI-1: Uses an 8-bit bus, and supports data rates of 4 MBps.
- SCSI-2: Same as SCSI-1, but uses a 50-pin connector instead of a 25-pin connector, and supports multiple devices.
- Ultra SCSI: Uses an 8- or 16-bit bus, and supports data rates of 20 or 40 MBps.
- Ultra2 SCSI: Uses an 8- or 16-bit bus and supports data rates of 40 or 80 MBps.
- Ultra3 SCSI: Uses a 16-bit bus and supports data rates of 80 or 160 MBps.
- Ultra160 SCSI: Uses a 16-bit bus and supports data rates of 160 MBps.

soft addressing. Pertaining to the Fibre Channel drive, a method that enables the drive to dynamically arbitrate its AL_PA with other Fibre Channel devices on the loop. The AL_PA enables the drive to communicate with other devices.

software. Programs, procedures, rules, and any associated documentation pertaining to the operation of a computer system.

Storage Area Network (SAN). A high-speed subnetwork of shared storage devices. A SAN's architecture makes all storage devices available to all servers on a LAN or WAN. As more storage devices are added to a SAN, they too will be accessible from any server in the larger network. Because stored data does not reside directly on any of a network's servers, server power is used for business applications, and network capacity is released to the end user.

subscription channel connector (SC). A push-pull type of optical connector that features high density, low loss, low backreflection, and low cost.

switch. A network infrastructure component to which multiple nodes attach. Unlike hubs, switches typically have the ability to switch node connections from one to another. A typical switch can facilitate several simultaneous bandwidth transmissions between different pairs of nodes.

T

TapeAlert. A patented technology and ANSI standard that defines conditions and problems that are experienced by tape drives.

TapeAlert flags. Status and error messages that are generated by the TapeAlert utility and display on the server's console.

tape cartridge. A removable storage case that houses belt-driven magnetic tape that is wound on a supply reel and a takeup reel.

tape drive. See *IBM Ultrium Internal Tape Drive Models T200 and T200F* or *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

tape path. Within a tape drive, the channel in which the media moves.

tapeutil. Created by IBM, a utility program for LTO devices that connect to all supported servers except Windows NT and Windows 2000. *tapeutil* provides service aids for tape subsystems, offers a menu-driven tool for exercising or testing IBM tape and medium changer devices, and includes a command-line interface that is convenient for use in shell scripts.

terminate. To prevent unwanted electrical signal reflections by applying a device (known as a terminator) that absorbs the energy from the transmission line.

topology. In communications, the physical or logical arrangement of nodes in a network, especially the relationships among nodes and the links between them.

TotalStorage LTO Ultrium Tape Drive Models T400 and T400F. See *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

transfer rate. See *data transfer rate*.

U

Ultrium Tape Drive. See *IBM Ultrium Internal Tape Drive Models T200 and T200F* or *IBM TotalStorage LTO Ultrium 2 Tape Drive Models T400 and T400F*.

Ultrium 2 Tape Drive. See *IBM TotalStorage LTO Ultrium 2 Tape Drive*.

uniform resource locator (URL). The address of an item on the World Wide Web. It includes the protocol followed by the fully qualified domain name (sometimes called the host name) and the request. The web server typically maps the request portion of the URL to a path and file name. For example, if the URL is `http://www.networking.ibm.com/nsg/nsgmain.htm`, the protocol is `http`; the fully qualified domain name is `www.networking.ibm.com`; and the request is `/nsg/nsgmain.htm`.

unload. The act (performed by the drive) of unthreading tape from the drive's internal tape path and returning it (with the leader block) to the tape cartridge.

URL. See *uniform resource locator*.

utility. See *utility program*.

utility program. A computer program that supports computer processes. For example, a diagnostic program, a trace program, or a sort program.

V

vital product data (VPD). Information about a product. Among other details, the VPD may include a model number, serial number, part number, or level of firmware.

W

web. See *World Wide Web*.

World Wide Name. A unique, 8-byte identifier that is assigned by IBM Manufacturing to each Ultrium Tape Drive and used to identify a drive.

World Wide Web. A network of servers that contain programs and files. Many of the files contain hypertext links to other documents that are available through the network.

write. To make a permanent or transient recording of data in a storage device or on a data medium.

write protected. Applicable to a tape cartridge, the condition that exists when some logical or physical mechanism prevents a device from writing on the tape in that cartridge.

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Printed in USA

GA32-0450-03